



Naiades (Mussels) of the Lower Osage River,
Tavern Creek, and Maries River, Missouri

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prepared by

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FOREWORD

The data used in the publication were collected for the U. S. Army Corps of Engineers, Kansas City District, under a Memorandum of Agreement between the U. S. Army Corps of Engineers and the Missouri Department of Conservation, during 1980 by Timothy B. Grace and Alan C. Buchanan of the Missouri Department of Conservation. Dr. David H. Stansbery of Ohio State University was a consultant for this project. A glossary of terms, diagram of a typical naiad life cycle, and an illustration of shell characters are provided at the back of this report.

The data provided in this report will be used by the U. S. Army Corps of Engineers, Kansas City District, to review and identify activities under its jurisdiction which may affect threatened or endangered naiades and their habitat in the lower Osage River Basin.

The findings in this report are strictly those of the authors and are not to be construed as the official U. S. Army Corps of Engineers' position. Mention of trade names or commercial products does not constitute U. S. Army Corps of Engineers endorsement or recommendation for use.

ABSTRACT

A survey of the naiades (mussels) at 43 sites in the lower Osage River Basin in central Missouri between May and September 1980 revealed a total of 36 species; 34 in the lower Osage River, 24 in Tavern Creek, and 26 in the Maries River. Three species, Anodonta grandis corpulenta, Arcidens confragosus, and Obovaria olivaria, all found in the lower Osage River, had not previously been reported from the lower Osage River Basin. A. g. corpulenta had not previously been reported from the Osage River Basin. Fusconaia ebena, previously collected in the lower Osage River Basin, was not found.

A total of 21,593 living naiades were examined: 18,038 at 23 sites in the lower Osage River, 1,284 at 9 sites in Tavern Creek, and 2,271 at 11 sites in the Maries River. Ten species of naiades comprised 92.0% of the living naiades found in the lower Osage River Basin: Megaloniais nervosa (51.5%), Amblema plicata plicata (9.1%), Quadrula pustulosa (8.1%), Cyclonaias tuberculata (4.9%), Lampsilis radiata luteola (4.8%), Lampsilis ventricosa (3.2%), Pleurobema coccineum (2.8%), Fusconaia flava (2.7%), Elliptio dilatata (2.6%), and Potamilus alatus (2.3%). M. nervosa, Q. pustulosa, C. tuberculata, and A. p. plicata were the dominant species in the lower Osage River; L. r. luteola, P. alatus, A. p. plicata, and L. ventricosa were the dominant species in Tavern Creek; and A. p. plicata, L. r. luteola, and L. ventricosa were the dominant species in the Maries River.

Lampsilis orbiculata, listed as endangered on the United States List of Endangered and Threatened Wildlife and Plants, was collected alive at nine sites in the lower Osage River. Live Cumerlandia monodonta, under Notice of Review for possible addition to the above list, were collected at seven sites in the lower Osage River. L. orbiculata and C. monodonta comprised 0.1% and 0.3%, respectively, of the living naiades found in the lower Osage River. These two species were not found in Tavern Creek or the Maries River. Four species, A. g. corpulenta, A. confragosus, Elliptio crassidens crassidens, and O. olivaria, classified as rare or endangered in Missouri, were also found in the lower Osage River.

The lower Osage River, Tavern Creek, and Maries River provide generally favorable habitat for naiades throughout most of their lengths except for reaches of the Osage River adjacent to three large, commercial gravel dredging operations and 16 miles of the main channel of the Osage River below Bagnell Dam. No living naiades were found in areas dredged by the three commercial gravel dredging operations. Removal and processing of sand and gravel at these dredging operations increases turbidity downstream during dredging and washing and increases the depth of the Osage River at the dredging site for an indefinite period of time. Continued gravel dredging in areas previously dredged at all three commercial dredging operations is unlikely to have a serious adverse impact on L. orbiculata and C. monodonta if the river configuration is not altered and dredging is not expanded downstream at Osage Sand and Gravel (river mile 65.0 to 68.0 left bank) and Roweth Sand and Gravel Company, Inc. (river mile 22.0 left bank). Instream gravel dredging should not be permitted at any new site on the lower Osage River without first conducting a survey of naiades at the site to determine the presence or absence of L. orbiculata and C. monodonta.

ACKNOWLEDGEMENTS

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INTRODUCTION

The primary objective of this study was to determine the distribution, relative abundance, and habitat requirements of Federally classified threatened or endangered species of naiades (mussels) which were known to occur, or thought likely to occur, in the lower Osage River, Tavern Creek, and the Maries River in the Osage River Basin in central Missouri (Fig. 1). The pink mucket pearly mussel, Lampsilis orbiculata (Hildreth 1828), presently listed as Endangered on the United States List of Endangered and Threatened Wildlife and Plants (United States Department of the Interior, Fish and Wildlife Service 1976) and the spectacle case, Cumberlandia monodonta (Say 1829), under Notice of Review for possible addition to the above list, are considered as species which meet these criteria. A secondary objective was to gather similar data for the other species of naiades found, and to evaluate the potential impacts of commercial gravel dredging operations on endangered naiades.

A search of published and unpublished reports was conducted to compile current knowledge on 1) the naiades in the Osage River Basin and 2) the effects of siltation and dredging on naiades.

STUDY AREA

Naiades were collected at sampling sites selected in the lower Osage River, Tavern Creek, and Maries River in central Missouri in Miller, Maries, Osage, and Cole counties (Fig. 2). These streams are all located in the Salem Plateau, a subdivision of the Ozark Uplands province (Fenneman 1938).

The Salem Plateau is underlain by Ordovician dolomites containing large quantities of chert, an almost insoluble material that remains when the surrounding rock is dissolved away. Gradually, chert fragments accumulate to substantial depths in the stream valleys, and later surface as large gravel bars in the streams.

The topography in this region is primarily rugged with narrow ridges and narrow stream valleys. Slopes are moderately steep. Soils are characteristically stoney or gravelly residual clays with alluvial soils in the river floodplains (Miller and Krusekopf 1929). Streams of the Salem Plateau are usually clear. The terrestrial vegetation is principally oak-hickory forest. Large acreages have been cleared for agricultural purposes, primarily pasture, although extensive sections are still forested.

The Osage River originates as the Marais des Cygnes River in east-central Kansas. The Marais des Cygnes flows eastward about 220 miles to its confluence with the Marmaton River in Vernon Co., Missouri, to form the Osage River. The Osage River from this point flows approximately 280 miles in an easterly direction to join the Missouri River 14 miles downstream from Jefferson City, Missouri. The Osage River Basin has a drainage area of 16,538 square miles (Stout and Hoffman 1973).

The study area on the lower Osage River extends from its mouth to Bagnell Dam at river mile 81.7 (Fig. 2). Bagnell Dam, completed in 1931, and Lake of the Ozarks are owned and operated by the Union Electric Company for hydroelectric power generation. The drainage area above Bagnell Dam is approximately 14,000 square miles. Water discharge at full pool, 659.1 ft. mean sea level (msl), varies from 449 cfs to 182,785 cfs (Hanson 1977). Water releases for the production of power come largely from the hypolimnion or lower layer of the reservoir. Therefore, the water released is usually cold, frequently less than 64°F.

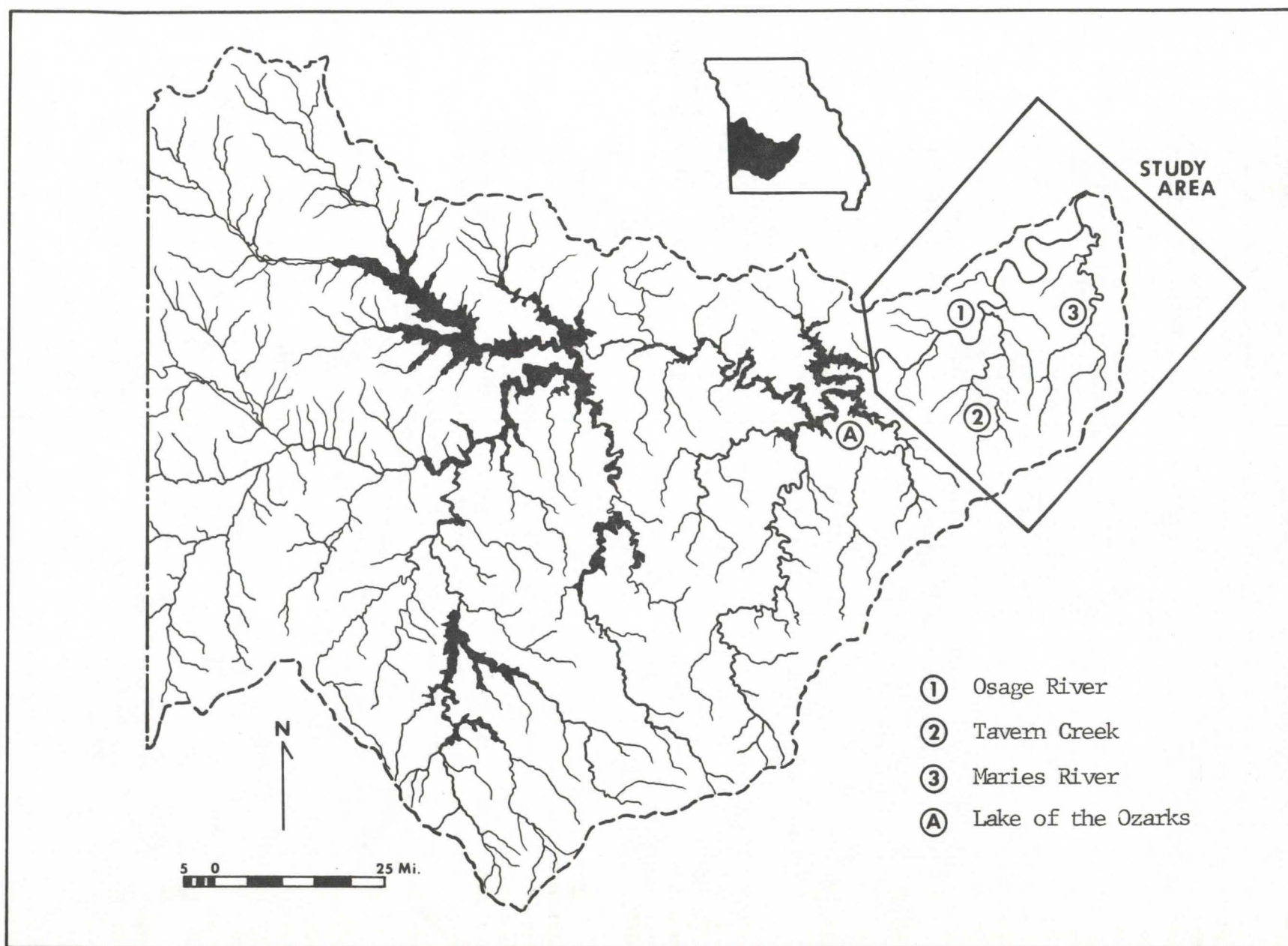


Figure 1. Osage River Basin, Missouri.

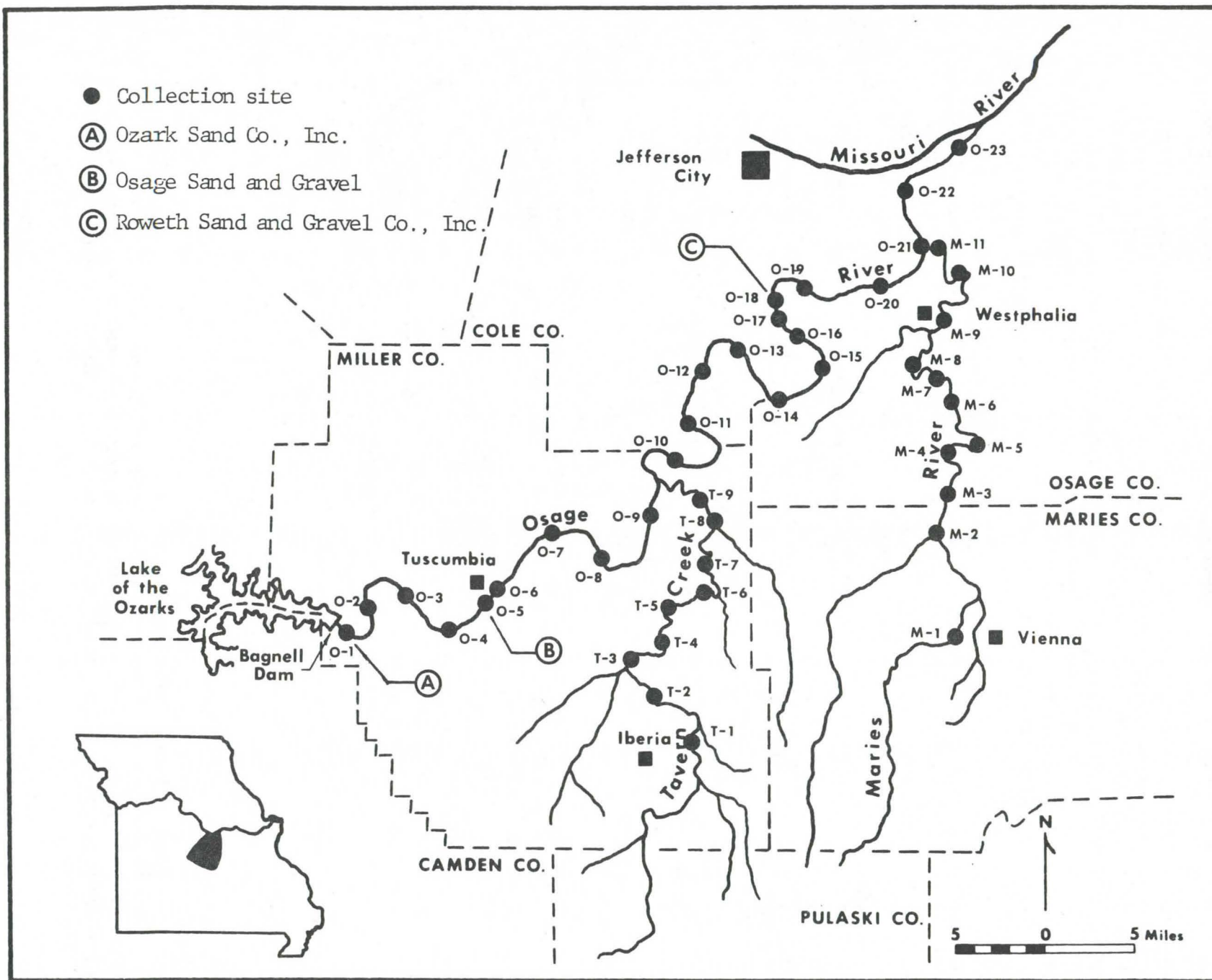


Figure 2. Collection sites in the lower Osage River, Tavern Creek, and Maries River and locations of commercial dredging operations.

The lower Osage River is a low gradient (average, 0.5 ft./mi.), moderately clear stream with long pools, usually less than 10 feet deep, and poorly defined riffles. Numerous islands and sloughs of varying size occur along the river. Gravel and cobble are the principal bottom types. Silt covers the riverbed in many of the deeper, sluggish pools and in backwater areas. Water willow (Justicia americana) is common along riffle areas and gravel bars. Dense beds of submerged vegetation, predominantly Potamogeton sp. and Najas sp., can be found throughout the river.

The Osage River was used for steamboat navigation during the early 1800's. Steamboats first began to use the Osage River in the late 1830's (Schultz 1937). Dikes were built and the channel deepened to improve the river for navigation. The General Assembly of Missouri appropriated money for the building of locks and dams on the Osage River in 1855 (Anon. 1889). Many dikes, some quite extensive, can be seen on the lower Osage River during low water levels. An old lock and dam (no longer operative) still spans the river at river mile 12.1.

The volume of flow, as mentioned earlier, of the lower Osage River is subject to large fluctuations. The discharge near St. Thomas during 1931 to 1979 ranged from 346 to 216,000 cfs, and averaged 9,942 cfs (United States Geological Survey 1980).

Water quality information was collected by the U. S. Geological Survey (1980) for the Osage River near St. Thomas during the 12-month period from October 1978 to September 1979. Alkalinity and total hardness ranged from 120 to 156 mg/l and from 130 to 193 mg/l, respectively. Water temperature varied from 34.0 to 80.5°F and dissolved oxygen varied from 4.3 mg/l (9 August 1979) to 12.7 mg/l (18 January 1979). Turbidity ranged from 2.5 to 20 JTU's and pH varied from 7.4 to 8.1.

Three commercial sand and gravel dredging operations are located on the lower Osage River (Fig. 2). Ozark Sand Company, Inc. is approximately 0.5 miles downstream from Bagnell Dam and extends from river mile 78.0 to 81.25. Osage Sand and Gravel is located near Tuscumbia, Missouri (between river miles 65.0 and 68.0). Roweth Sand and Gravel Company, Inc. is located approximately 3.0 miles SSE of Wardsville, Missouri, at river mile 22.0. All three plants are situated on the left descending bank.

Ozark Sand Co. removes sand and gravel from the river with a crane-dragline dredge and a crane with bucket. The material is loaded into trucks and hauled to a nearby processing plant where it is washed and separated using river water. This water is returned to the river via a settling pond.

Osage Sand and Gravel hydraulically removes sand and gravel from the river with a cutterhead dredge. The dredged material is pumped through a pipeline mounted on floating pontoons to the processing site on shore. River water is used in washing and separating the dredged material. The water pumped to shore with the sand and gravel and the water used to wash and separate this material was returned directly to the river at the time of this study. Settling basins have since been installed and are expected to reduce the sediment load in future discharges.

Roweth Sand and Gravel Co. removes sand and gravel from the river with a Sauerman dragline dredge. The dredged material is washed and separated at a processing site on shore using river water. This water is returned directly to the river.

The two largest tributaries of the lower Osage River are Tavern Creek and Maries River (Fig. 2). Tavern Creek and the Maries River have axial stream lengths of 53 and 63 miles, respectively. The survey area extends from the mouth of each stream to Highway 42 (river mile 32.8 on Tavern Creek and river mile 43.0 on the Maries River). Both are typical, clear Ozark streams. There is a lengthening and deepening of the pools with riffles becoming less frequent from the headwaters to the mouth. The bottom type in the upper parts of these streams is predominately gravel, with sand and cobble in the pools and gravel and cobble in riffles. The substrate is usually unstable. The pools are generally gravel-, sand-, and silt-bottomed and the riffles consist of gravel and sand further downstream. The average discharge of the Maries River at Westphalia during 1948 to 1970 was 211 cfs (United States Geological Survey 1970). The maximum discharge during this period was 26,100 cfs and the minimum was 0.1 cfs. The drainage area above Westphalia is 257 mi.² No discharge data is available for Tavern Creek. Thick growths of water willow (Justicia americana) occur along both these streams and filamentous algae is found in the clearer water.

PRIOR COLLECTIONS OF NAIADES IN THE OSAGE RIVER BASIN, MISSOURI

Information on the distribution of naiades in the Osage River Basin was obtained from published and unpublished sources. Table 1 is a summary of prior collections of naiades in the Osage River Basin, Missouri. Previous collection sites in the lower Osage River, Tavern Creek, and the Maries River are shown in Figure 3.

Utterback (1915, 1917) provided the earliest information on naiades found in the Osage River Basin. He found 34 species in the basin; six of these occurred in the lower Osage River. He reported Cumberlandia monodonta from the Osage River at Warsaw, Sagra, and Bagnell, Missouri. The collection sites at Warsaw and Sagra (no longer a town) have since been inundated by Lake of the Ozarks. Unfortunately, Utterback did not record all the localities at which he found each species and his collections and notes have since been lost.

Stein (Stansbery 1973) made collections in 1964 at five sites previously collected by Utterback (1915) on the Osage River. She found a total of 27 species at these sites. She found eight, fifteen, and nine species, respectively, at Bagnell, Tuscumbia, and Osage City, Missouri.

Stansbery (1973) identified naiades collected in 1973 by the U. S. Army Corps of Engineers, Kansas City District, from the Osage River Basin above Warsaw, Missouri. Twenty-six species were found at 20 sites sampled.

Oesch (in press) has collected naiades at a number of sites in the Osage River Basin. Thirty-nine species were found in the basin. He found Lampsilis orbiculata in the Sac River, a tributary to the Osage River. He collected 22 species in the lower Osage River, including C. monodonta near Tuscumbia, Missouri. He reported 18 species in Tavern Creek and 14 species in the Maries River.

Duchrow (in preparation) collected naiades during a water quality survey of the Osage River Basin in Missouri. Although not specifically looking for naiades, he found 34 species in the basin, including 13 species in the lower Osage River, 6 species in Tavern Creek, and 12 species in the Maries River.

Table 1. Species of naiades in the Osage River Basin, lower Osage River, Tavern Creek and Maries River as reported in previous studies in Missouri.

Species	Osage Basin ^a	Lower Osage River ^b	Tavern Creek ^c	Maries River ^d
Cumberlandia monodonta	X	X		
Anodonta imbecillis	X	X		X
Anodonta g. grandis	X		X	X
Strophitus u. undulatus	X	X	X	
Alasmidonta marginata	X			
Alasmidonta viridis	X			
Arcidens confragosus	X			
Lasmigona complanata	X	X	X	X
Lasmigona costata	X		X	X
Megaloniaias nervosa	X	X		
Tritogonia verrucosa	X	X	X	X
Quadrula quadrula	X	X		
Quadrula metanevra	X	X		
Quadrula nodulata	X			
Quadrula pustulosa	X	X	X	X
Amblema p. plicata	X	X	X	X
Fusconaia ebena	X	X		
Fusconaia flava	X	X	X	X
Fusconaia ozarkensis	X			
Cycloniaias tuberculata	X	X		
Pleurobema coccineum	X	X	X	X
Elliptio c. crassidens	X	X		
Elliptio dilatata	X	X		X
Unio merus tetralasmus	X			
Ptychobranhus occidentalis	X			
Obliquaria reflexa	X	X		
Actinoniaias ligamentina carinata	X	X		
Venustaconcha e. ellipsiformis	X	X	X	X
Plagiola lineolata	X	X		
Obovaria olivaria	X			
Truncilla truncata	X	X		
Truncilla donaciformis	X	X		
Leptodea fragilis	X	X	X	X
Potamilus alatus	X	X	X	X
Potamilus ohioensis	X	X	X	
Toxolasma parvus	X			
Ligumia recta	X	X	X	X
Ligumia subrostrata	X			X
Lampsilis t. teres	X	X	X	X
Lampsilis t. anodontoides	X			
Lampsilis radiata luteola	X		X	X
Lampsilis ventricosa	X	X	X	X
Lampsilis orbiculata	X	X		
Lampsilis reeviana brittsi	X	X	X	
Total species	44	30	18	18

Table 1 (Continued).

- ^a Utterback (1917); Stansbery (1973); Oesch (in press); Duchrow (in preparation); Buchanan et al. (unpublished data).
- ^b Utterback (1915); Stansbery (1973); Oesch (in press); Duchrow (in preparation); Buchanan et al. (unpublished data).
- ^c Oesch (in press); Duchrow (in preparation).
- ^d Oesch (in press); Duchrow (in preparation); Buchanan et al. (unpublished data).

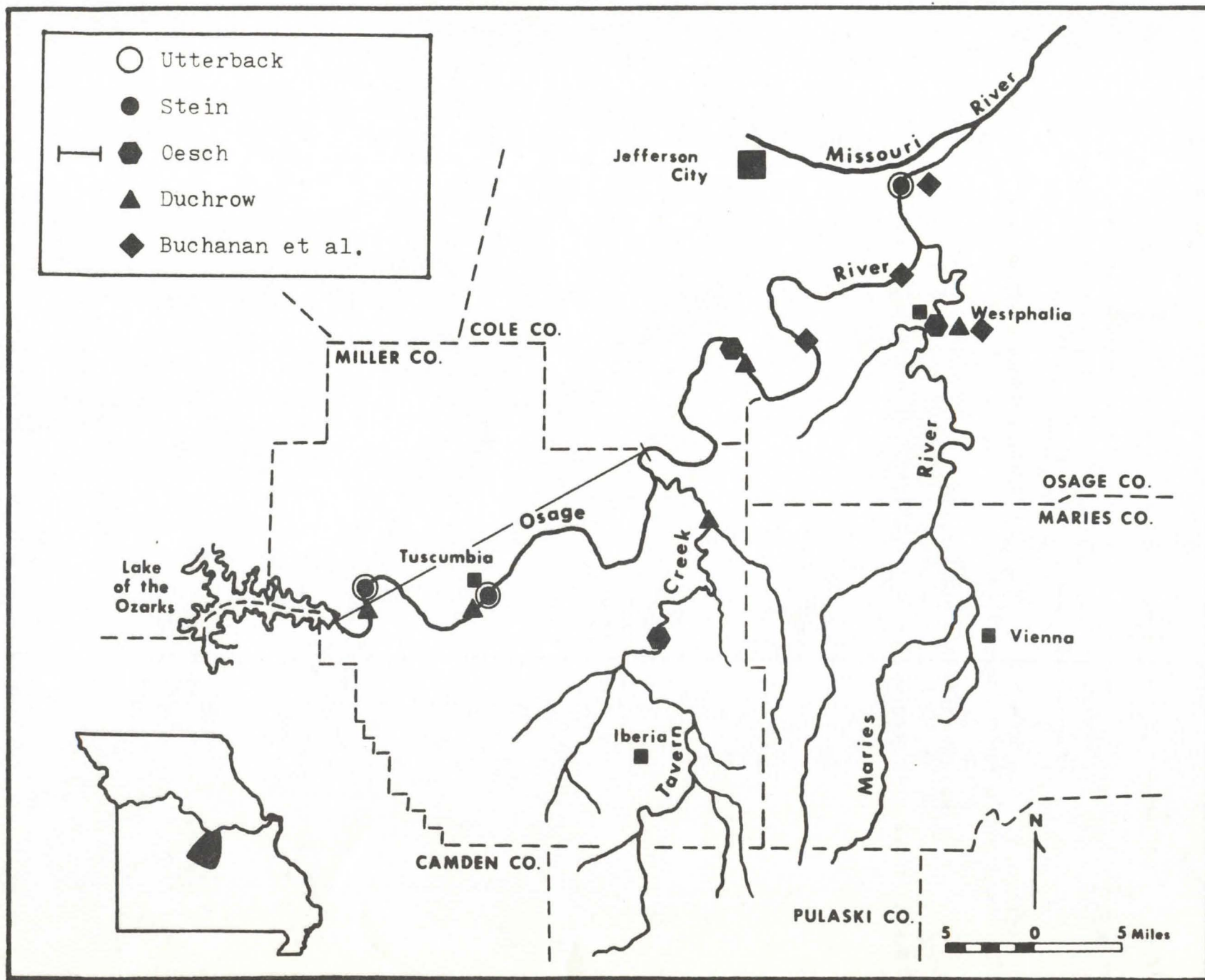


Figure 3. Sites previously collected in the lower Osage River, Tavern Creek, and Maries River.

Buchanan and other employees of the Missouri Department of Conservation (unpublished data) have collected naiades at several sites in the Osage River Basin prior to this study. Nine collections, all made in 1978, contained 33 species. L. orbiculata was collected at two sites and C. monodonta at one site in the Sac River. Twenty-five species were found at three sites in the lower Osage River. L. orbiculata was found at two of these sites, river miles 12.1 and 23.7. C. monodonta was also found at river mile 12.1. One collection in the Maries River contained 14 species.

EFFECTS OF SILTATION AND DREDGING ON NAIADES

A review of the literature on the impacts of dredging upon naiades revealed a scarcity of information. Previous studies have shown that naiades may be impacted by suspended silt and coverings of silt, sand, and other materials, but only a single study directly related silt produced by gravel dredging to an adverse impact upon naiades.

The adverse affects of siltation and sedimentation upon naiades has been well documented in previous studies. Ellis (1931a) stated that the "outstanding factor producing changes in the Mississippi River fauna seems to be that of erosion silt". Ellis (1931b) contended that thin deposits of erosion silt smothers young naiades and thick deposits smother both young and adult naiades. He also reported that silt traps organic material in the substrate, creating an oxygen demand at the bottom of streams to the detriment of naiades, especially young individuals. Van der Schalie (1938, 1941) and Stansbery (1970) believe that siltation resulting from land clearing and farming have adversely affected naiades in the eastern United States.

Siltation has adversely affected naiades in the Illinois River. Danglade (1914) found several areas in the Illinois River where substantial concentrations of naiades had been destroyed by sedimentation. Starrett (1971) reported that four species, the ladyfinger (Elliptio dilatata), mucket (Actinonaias ligamentina carinata), pocketbook (Lampsilis ventricosa), and Higgin's eye pearly mussel (Lampsilis higginsii), have been eliminated, and three species, the hickory-nut (Obovaria olivaria), rainbow shell (Villosa iris iris), and slough sand-shell (Lampsilis teres teres), are less widely distributed due to pollution and siltation.

Several laboratory experiments have been conducted to determine the effects of silt on mollusks. Ellis (1936) found that "common" naiades were unable to survive, in either sand or gravel bottoms, when a layer of silt from one-fourth inch to one-inch in depth was allowed to accumulate over them, other conditions being favorable to survival. The yellow sand-shell (Lampsilis teres anodontoides) was most readily killed; the more resistant species were: the three-horned warty-back (Obliquaria reflexa), the maple-leaf (Quadrula quadrula), and the monkey-face (Quadrula metanevra). Ellis also studied the effect of suspended silt on naiades. He found that silt interfered with feeding and respiration. Naiades in water containing suspended silt remained closed a larger percent of the time than those in silt-free water. Naiades in silt-laden water produced excessive mucous secretions and those that died had deposits of silt in the mantle cavity and frequently in the gill chamber.

Loosanoff and Tommers (1948) and Loosanoff (1962) examined the effects of suspended particulate matter on the feeding rate of marine bivalves under laboratory conditions. They found that the addition of silt caused a reduction in the pumping rate and therefore the feeding rate. Loosanoff (1962) concluded that lamellibranchs (bivalve mollusks) feed most effectively in relatively clear water.

Imlay (1972) reported increased mortality in naiades covered with detritus, sand, silt, and "grit". No individuals of the floater, Anodonta grandis grandis, emerged from a covering of seven inches of silt (22 of the 24 buried specimens died) and only one individual emerged from a covering of seven inches of sand (26 of the 27 specimens buried died) after 19 days.

Marking and Bills (1980), in another laboratory study, covered pig-toes (Fusconaia flava), fat mucklets (Lampsilis radiata luteola), and pocketbooks (Lampsilis ventricosa) with 2 to 10 inches of sand and silt in 2-inch increments. Naiades were in upright positions in a sand substrate prior to the addition of sand or silt. They concluded that over 50 percent of the L. r. luteola and L. ventricosa are capable of emerging from sand or silt deposits of about 7 inches, and 45 percent of the F. flava can emerge from a 4-inch silt deposit.

Dredging may impact naiades by physically removing them from the substrate or by producing silt which covers them. Stein (1972) found live specimens of 17 species of naiades at a site in the Olentangy River, Columbus, Ohio, in the early 1960's. Live specimens of only two species were found at the site in 1971, three years after the site was dredged to facilitate construction of a highway bridge.

Yokley and Gooch (1976), during a study of the effects of gravel dredging on naiades in the Tennessee River, attributed the slower growth rate in Fusconaia ebena downstream from a gravel dredging site to the poorer water quality. Wash water from the dredging operation was returned directly to the river, leaving silt in suspension below the dredging site. A hydraulic dredge was used for gravel removal. They believed at least ten years would be required for a dredged area to recover, depending on the stabilization of the riverbed and its attractiveness to fish hosts carrying larval naiades.

Fuller (1978) conducted a survey of naiades in the Minnesota, St. Croix, and Upper Mississippi rivers for the U. S. Army Corps of Engineers, St. Paul and Rock Island districts. He concluded that channel maintenance (dredging and associated activities) has "only a minor impact on naiades, including the legally protected species". Fuller believes the adverse impact of dredging on naiades will remain minor if careful planning continues in the future.

Perry (1979), during a survey of naiades in the Upper Mississippi River, felt siltation and hydraulic dredging had destroyed concentrations of naiades and decreased diversity. Perry reported finding naiades that could tolerate some sedimentation. He found live specimens of three-ridge (Amblema plicata plicata), pigtoe (Fusconaia flava), and pocketbook (Lampsilis ventricosa) naiades buried under six inches of silt, and the paper pond shell (Anodonta imbecillis), heel splitter (Anodonta suborbiculata), and lilliput mussel (Toxolasma parvus) surviving on silt substrates. Perry believes gravel mining should be examined more closely in the future and surveys and planning should precede any dredging or filling activity.

Dredging activities which impact fish also indirectly impact naiades, since naiades depend upon fish for reproduction and dispersal. Any activity that causes a fish host to avoid or leave an area must be considered when assessing the impacts of gravel dredging on naiades. If fish hosts are adversely affected by dredging activities, then naiades likewise would be adversely affected.

MATERIALS AND METHODS

Naiades were collected at 43 sites (Fig. 2) in the lower Osage River, Tavern Creek, and Maries River between 12 May and 23 September, 1980. Systematic sampling was done at 3- to 5-mile intervals on each stream. Special

emphasis was given to river reaches in the vicinity of existing and proposed dredging operations on the Osage River. Site localities and sampling dates are listed in Appendix A.

Shells were collected by hand along shore, from muskrat and raccoon piles, and from the bottom of the stream at each collection site. Live naiades were collected by hand while wading, snorkeling, and SCUBA diving until representatives of all species present had been collected. The majority of collecting was done by hand in Tavern Creek and the Maries River while wading with a benthoscope (viewing box). Most collecting was done by hand while SCUBA diving in the Osage River.

The following information was recorded at each sampling site: date, location, name(s) of collector(s), area covered by the site, bottom type(s) in areas where living naiades were found, water temperature, water depth, collection techniques, the number of living and dead specimens of each species retained as vouchers, and the number of living specimens of each species returned to the water. All sites were photographed and recorded on United States Geological Survey topographic maps.

Alkalinity, total hardness, pH, and dissolved oxygen were determined with a Hach Ecology Kit Model AL-36B, turbidity was measured with a Hach Laboratory Turbidimeter Model 1860, and current velocity was measured with a Pygmy Current Meter at each site. Current velocity was measured at mid-depth in water less than 6 inches deep, and at the surface and bottom in water greater than 6 inches deep in most cases.

One or more specimens of each species collected were retained as vouchers at each site. Specimens of Lampsilis orbiculata were cleaned, aged, and sexed. Specimens collected were listed as either live, dead, weathered dead, or subfossil. Live specimens were preserved as vouchers or returned to the water. Dead Specimens consisted of shell material with a shiny nacre (innermost layer of the shell) and the periostracum (outermost layer of the shell) relatively intact. Weathered dead specimens consisted of shell material with a slightly chalky nacre, but with the periostracum relatively intact. Subfossil specimens consisted of shell material in which the nacre was chalky or absent, and the periostracum had, to some extent, peeled from the shell.

Naiades were collected intensively at each commercial gravel dredging site. Qualitative sampling was conducted above, within, and directly below each operation, primarily using SCUBA. A minimal amount of quantitative collecting, utilizing quadrat sampling and SCUBA diving, was also done to later compare the density of naiades in areas affected and unaffected by dredging operations.

A series of sampling transects were established across the river at each dredging operation. Equally spaced 5.7 ft.² quadrats were examined for naiades along each transect. Naiades were identified, counted, and kept or returned to the riverbed. Quantitative sampling was conducted at three sites not affected by dredging.

Turbidity was monitored on 3 days each at Ozark Sand Co. and Roweth Sand and Gravel Co. and 4 days at Osage Sand and Gravel in order to determine the impact of dredging activities upon the turbidity of the Osage River. Stations were selected 250 ft. above (Station I) and 250 ft. below (Station II) the dredging site at each dredging operation. Four additional stations, 800 ft. (Station III), 3,700 ft. (Station IV), 4,800 ft. (Station V), and 7,200 ft. (Station VI) downstream from the dredging equipment, were established at Ozark Sand Co. (Fig. 4). Additional stations were likewise established at Osage Sand and Gravel, 1,350 ft. (Station III), 4,100 ft. (Station IV), and 6,100

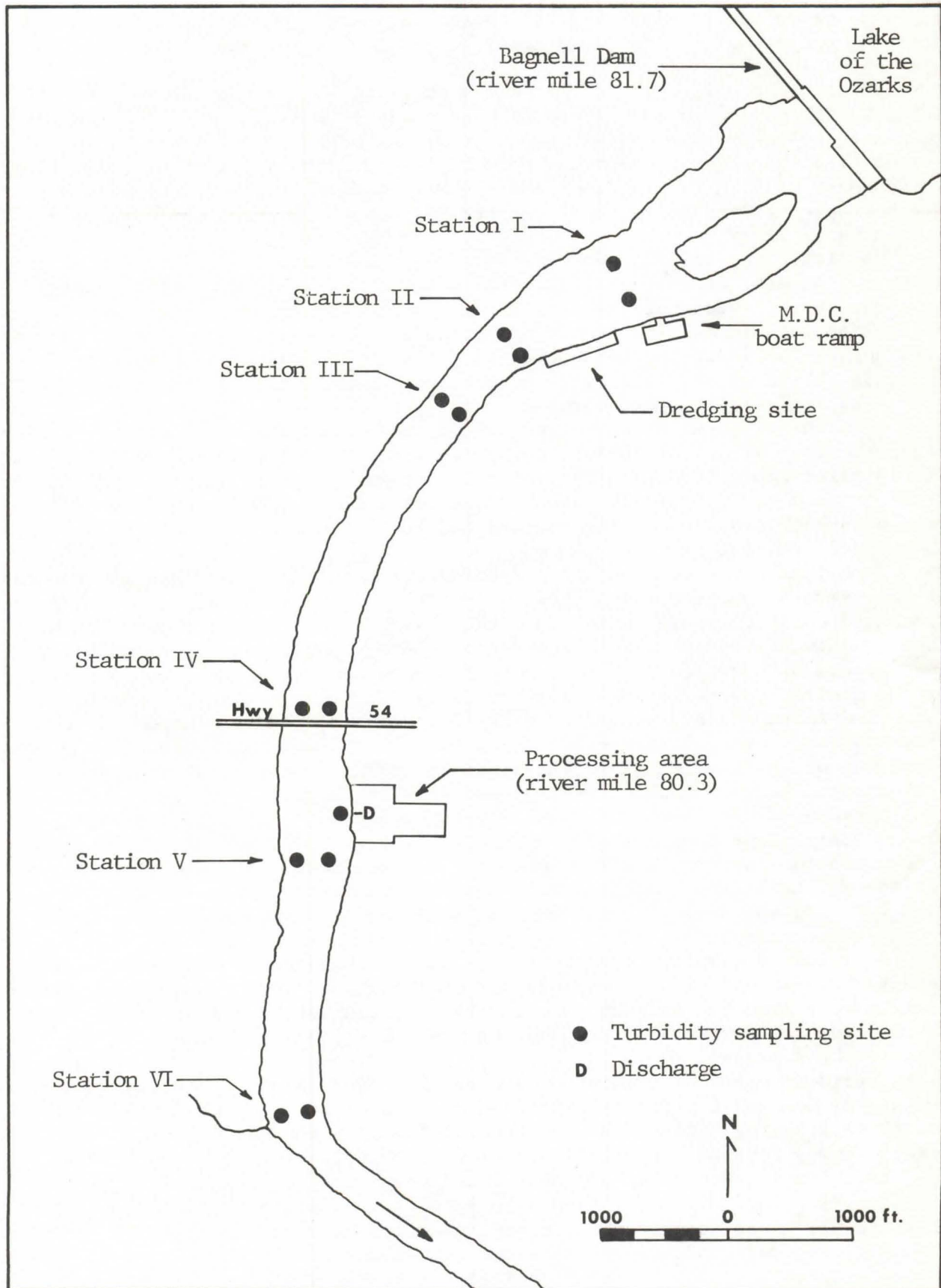


Figure 4. Turbidity sampling sites at Ozark Sand Co., Osage River.

ft. (Station V) below the dredge (Fig. 5), and at Roweth Sand and Gravel Co., 1,150 ft. (Station III), 3,300 ft. (Station IV), and 5,400 ft. (Station V) downstream from the dragline (Fig. 6). All stations remained fixed throughout the study except for the stations located 250 ft. above and 250 ft. below the dredging site at Ozark Sand Co. The dredging equipment at this operation was moved short distances during the study and a corresponding move of these two stations was made so that their positions would always remain the same in relation to the dredging activity.

Water samples were collected each day at all stations before dredging and washing activities began and throughout the day at 2-hour intervals. Water samples were collected from the surface and bottom at two sites, approximately one-third the distance from each shore at each station. Water discharged from each operation was also sampled before it entered the river.

The river bottom was sounded at each dredging operation. Transects were marked off at 100 ft. intervals and a rope with buoys spaced 25 ft. apart was stretched across the river. The river width was determined, the river was sounded, and the bottom depth (noted at each buoy) and configuration were recorded on chart paper with a Lowrance Model LRG 610A Flasher-Graph (depth finder) at each transect.

RESULTS AND DISCUSSION

Thirty-six species of naiades were found during this study (Table 2); 34 in the lower Osage River, 24 in Tavern Creek, and 26 in the Maries River. Lampsilis orbiculata, listed as Endangered on the United States List of Endangered and Threatened Wildlife and Plants (United States Department of the Interior, Fish and Wildlife Service 1976) and Cumberlandia monodonta, under Notice of Review for possible addition to the above list, were found in the lower Osage River. Four species, Anodonta grandis corpulenta, Arcidens confragosus, Elliptio crassidens crassidens, and Obovaria olivaria, classified as rare or endangered in Missouri (Missouri Department of Conservation 1977) were also found in the lower Osage River.

A total of 21,593 living naiades were examined in the study area, 18,038 in the lower Osage River, 1,284 in Tavern Creek, and 2,271 in the Maries River (Table 3). Ten species of naiades comprised 92.0% of the living naiades found in the lower Osage River, Tavern Creek, and Maries River: Megaloniais nervosa (51.5%), Amblema plicata plicata (9.1%), Quadrula pustulosa (8.1%), Cycloniais tuberculata (4.9%), Lampsilis radiata luteola (4.8%), Lampsilis ventricosa (3.2%), Pleurobema coccineum (2.8%), Fusconaia flava (2.7%), Elliptio dilatata (2.6%), and Potamilus alatus (2.3%). These species were found at 24, 39, 28, 19, 29, 40, 25, 33, 27, and 40 sites, respectively, of the 43 sites sampled (based on all material found).

The species and numbers of naiades found at each collection site are listed in Appendix B.

Lower Osage River

Thirty-four species of naiades were found in the lower Osage River during this study (Table 2), including one nationally endangered species, L. orbiculata, one species under Notice of Review for possible addition to the U. S. List of Endangered and Threatened Wildlife and Plants, C. monodonta, and four species, A. g. corpulenta, A. confragosus, E. c. crassidens, and O. olivaria, classified as rare or endangered in Missouri. L. orbiculata was collected at 16 sites between river miles 5.9 and 79.5 (Figure 10); 17 living specimens were examined

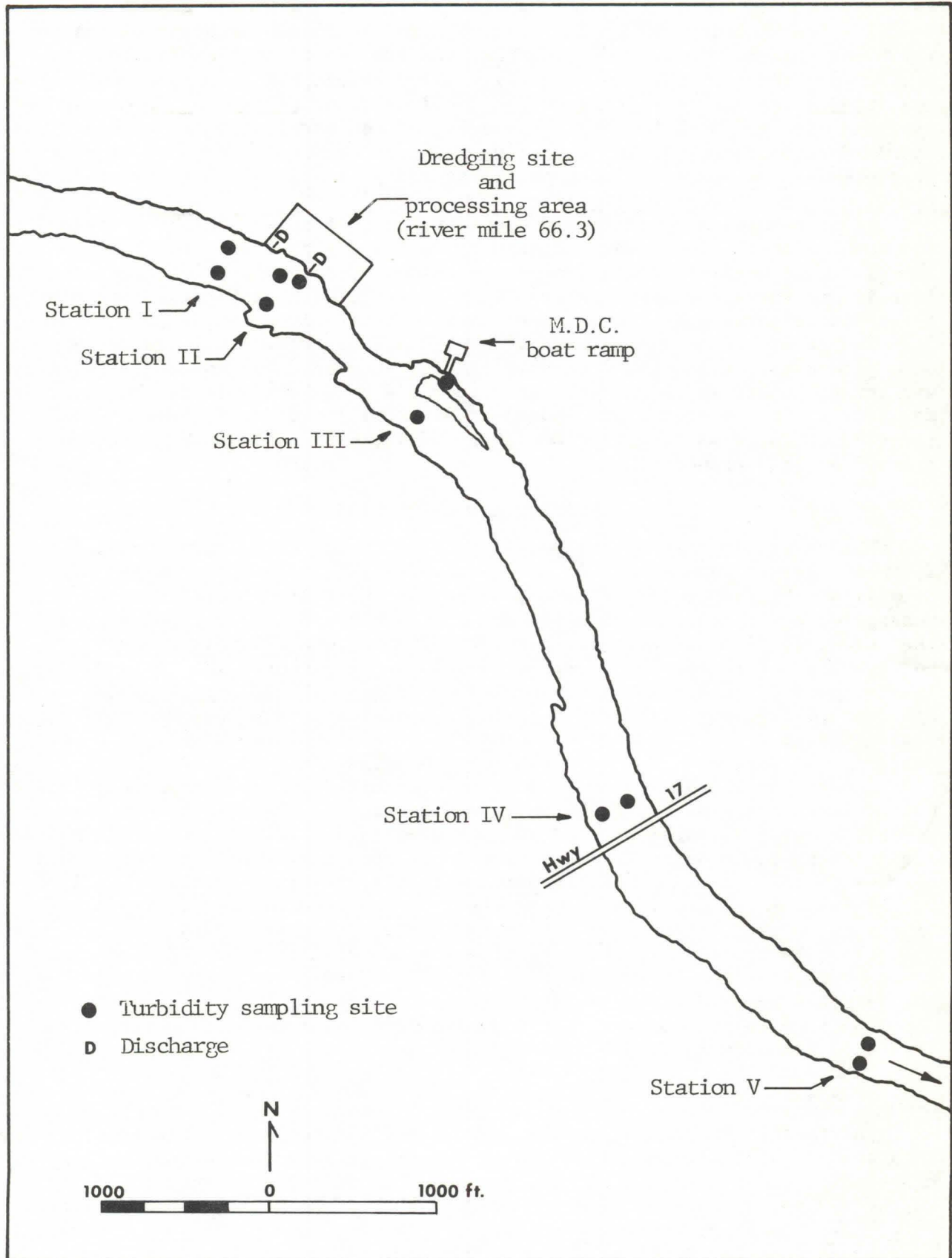


Figure 5. Turbidity sampling sites at Osage Sand and Gravel, Osage River.

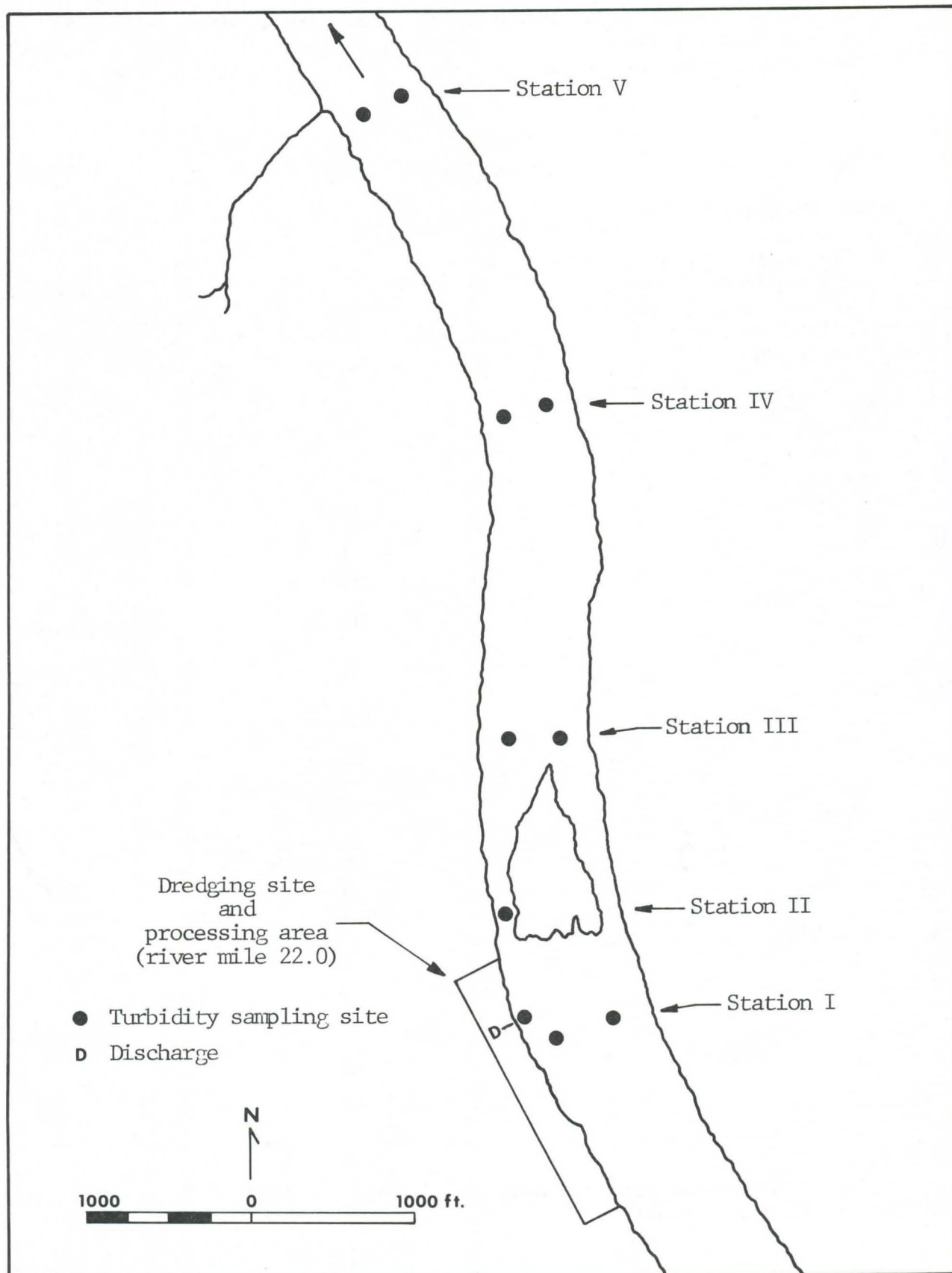


Figure 6. Turbidity sampling sites at Roweth Sand and Gravel Co., Osage River.

Table 2. Species of naiades found in the lower Osage River, Tavern Creek, and Maries River. The freshest specimen found is indicated as Living (L), Dead (D), Weathered Dead (WD), or Subfossil (SF).

<u>Species</u>	<u>Lower Osage River</u>	<u>Tavern Creek</u>	<u>Maries River</u>	<u>Status</u>
Cumberlandia monodonta	L	-	-	Rare-Mo. ^a
Anodonta imbecillis	L	L	L	
Anodonta g. grandis	L	L	L	
Anodonta grandis corpulenta	L	-	-	Endangered-Mo.
Strophitus u. undulatus	L	L	L	
Arcidens confragosus	SF	-	-	Endangered-Mo.
Lasmigona complanata	L	L	L	
Lasmigona costata	L	L	L	
Megalonaias nervosa	L	-	L	
Tritogonia verrucosa	L	L	L	
Quadrula quadrula	L	-	L	
Quadrula metanevra	L	-	-	
Quadrula pustulosa	L	L	L	
Amblema p. plicata	L	L	L	
Fusconaia flava	L	L	L	
Cyclonaias tuberculata	L	WD	-	
Pleurobema coccineum	L	L	L	
Elliptio c. crassidens	L	-	-	Endangered-Mo.
Elliptio dilatata	L	L	L	
Obliquaria reflexa	L	L	L	
Actinonaias ligamentina carinata	L	L	L	
Venustaconcha e. ellipsiformis	L	L	L	
Plagiola lineolata	L	-	-	
Obovaria olivaria	SF	-	-	Rare-Mo.
Truncilla truncata	L	D	L	
Truncilla donaciformis	L	-	-	
Leptodea fragilis	L	L	L	
Potamilus alatus	L	L	L	
Potamilus ohioensis	L	-	L	
Ligumia recta	L	L	L	
Ligumia subrostrata	-	L	L	
Lampsilis t. teres	L	L	L	
Lampsilis radiata luteola	L	L	L	
Lampsilis ventricosa	L	L	L	
Lampsilis orbiculata	L	-	-	Endangered-U.S.
Lampsilis reeviana brittsi	-	L	L	
Total species	34	24	26	

^a Under Notice of Review for possible addition to the U.S. List of Endangered and Threatened Wildlife and Plants.

Table 3. The numbers and relative abundance of living naiades found in the lower Osage River, Tavern Creek, Maries River, and the entire Study Area. The total number of sites at which each species was collected living and living and/or dead are listed.

Species	Lower Osage River		Tavern Creek		Maries River		Study Area		Total number of sites at which each species was found living. ^a	Total number of sites at which each species was found living ^a and/or dead. ^a
	No.	%	No.	%	No.	%	No.	%		
Cumberlandia monodonta	46	0.3	0	0	0	0	46	0.2	7	8
Anodonta imbecillis	1	*	1	0.1	6	0.3	8	*	4	5
Anodonta g. grandis	39	0.2	8	0.6	142	6.3	189	0.9	24	25
Anodonta grandis corpulenta	8	*	0	0	0	0	8	*	3	3
Strophitus u. undulatus	3	*	9	0.7	12	0.5	24	0.1	14	20
Arcidens confragosus	0	0	0	0	0	0	0	0	0	3
Lasmigona complanata	41	0.2	1	0.1	12	0.5	54	0.3	15	22
Lasmigona costata	1	*	49	3.8	26	1.1	76	0.4	10	14
Megaloniaias nervosa	11,116	61.6	0	0	1	*	11,117	51.5	22	24
Tritogonia verrucosa	57	0.3	23	1.8	10	0.4	90	0.4	21	25
Quadrula quadrula	38	0.2	0	0	3	0.1	41	0.2	20	25
Quadrula metanevra	344	1.9	0	0	0	0	344	1.6	18	21
Quadrula pustulosa	1,719	9.5	5	0.4	20	0.9	1,744	8.1	24	28
Amblema p. plicata	914	5.1	154	12.0	893	39.3	1,961	9.1	37	39
Fusconaia flava	552	3.1	17	1.3	14	0.6	583	2.7	29	33
Cyclonaias tuberculata	1,057	5.9	0	0	0	0	1,057	4.9	14	19
Pleurobema coccineum	609	3.4	1	0.1	3	0.1	613	2.8	23	25
Elliptio c. crassidens	3	*	0	0	0	0	3	*	2	3
Elliptio dilatata	359	2.0	58	4.5	135	5.9	552	2.6	24	27
Obliquaria reflexa	45	0.2	2	0.2	2	0.1	49	0.2	17	26
Actinonaias ligamentina carinata	58	0.3	1	0.1	2	0.1	61	0.3	15	20
Venustaconcha e. ellipsiformis	6	*	49	3.8	80	3.5	135	0.6	15	21
Plagiola lineolata	114	0.6	0	0	0	0	114	0.5	14	22
Obovaria olivaria	0	0	0	0	0	0	0	0	0	5
Truncilla truncata	67	0.4	0	0	7	0.3	74	0.3	13	20
Truncilla donaciformis	3	*	0	0	0	0	3	*	2	4

Table 3. (Continued.)

Species	Lower Osage River		Tavern Creek		Maries River		Study Area		Total number of sites at which each species was found living. ^a	Total number of sites at which each species was found living and/or dead. ^a
	No.	%	No.	%	No.	%	No.	%		
<i>Leptodea fragilis</i>	78	0.4	17	1.3	25	1.1	120	0.6	28	32
<i>Potamilus alatus</i>	231	1.3	209	16.2	54	2.4	494	2.3	40	40
<i>Potamilus ohiensis</i>	38	0.2	0	0	2	0.1	40	0.2	5	6
<i>Ligumia recta</i>	104	0.6	4	0.3	7	0.3	115	0.5	21	24
<i>Ligumia subrostrata</i>	0	0	1	0.1	6	0.3	7	*	5	5
<i>Lampsilis t. teres</i>	14	0.1	46	3.6	54	2.4	114	0.5	17	26
<i>Lampsilis radiata luteola</i>	10	0.1	484	37.7	539	23.7	1,033	4.8	26	29
<i>Lampsilis ventricosa</i>	346	1.9	137	10.7	213	9.4	696	3.2	38	40
<i>Lampsilis orbiculata</i>	17	0.1	0	0	0	0	17	0.1	9	16
<i>Lampsilis reeviana brittsi</i>	0	0	8	0.6	3	0.1	11	0.1	5	5
Total living specimens	18,038		1,284		2,271		21,593			

^aForty-three sites sampled.

* Less than 0.1% of total.

at nine of these sites (Table 3). C. monodonta was collected at eight sites between river miles 13.6 and 65.0 (Figure 11); 46 living specimens were examined at seven of these sites (Table 3). The four Missouri rare or endangered species were found at the following localities: A. g. corpulenta between river miles 5.6 and 69.0 (Figure 14), A. confragosus between river miles 10.3 and 52.1 (Figure 16), E. c. crassidens between river miles 21.5 and 77.6 (Figure 29), and O. olivaria between river miles 17.6 and 80.8 (Figure 35). No live specimens of A. confragosus or O. olivaria were found (Table 3).

Six species, Anodonta grandis grandis, A. g. corpulenta, A. confragosus, Lasmigona costata, O. olivaria, and L. r. luteola, had not been reported in the lower Osage River. A. g. corpulenta had not been reported in the Osage River Basin. Fusconaia ebena and Lampsilis reeviana brittsi, previously found in low numbers in the lower Osage River (Oesch in press, Buchanan et al. unpublished data), were not found.

Six species comprised 88.6% of the living naiades found in the lower Osage River: M. nervosa (61.6%), Q. pustulosa (9.5%), C. tuberculata (5.9%), A. p. plicata (5.1%), P. coccineum (3.4%), and F. flava (3.1%) (Table 3). These species were found at 23, 23, 18, 23, 21, and 22 sites, respectively, of the 23 sites sampled (based on all material found). L. orbiculata and C. monodonta comprised only 0.1% and 0.3%, respectively, of the living naiades found in the lower Osage River (Table 3).

The main channel of the Osage River between river mile 81.7 (Bagnell Dam) and 66.0 (Tuscumbia, Missouri) appears to provide poor habitat for naiades. No concentrations of naiades were found in the main channel at four collection sites, 0-1, 0-2, 0-3, and 0-4, in this river reach. Naiades were usually found in shallow water near shore, in side channels, or below islands. Concentrations of naiades downstream from river mile 66.0, however, were generally found in the main channel.

The scarcity of naiades in the main channel above river mile 66.0 may be attributed to the cold-water releases and high discharges from Bagnell Dam, especially during hydroelectric power generation. Areas off the main channel may provide more stable habitat and warmer water.

Tavern Creek

Twenty-four species of naiades were found in Tavern Creek (Table 2). Seven species, Anodonta imbecillis, Cyclonaias tuberculata, Elliptio dilatata, Obliquaria reflexa, Actinonaias ligamentina carinata, Truncilla truncata, and Ligumia subrostrata, had not been reported in Tavern Creek. Potamilus ohioensis, previously collected in Tavern Creek (Oesch in press), was not found.

Eight species comprised 92.3% of the living naiades found in Tavern Creek: Lampsilis radiata luteola (37.7%), Potamilus alatus (16.2%), Amblema plicata plicata (12.0%), Lampsilis ventricosa (10.7%), Elliptio dilatata (4.5%), Lasmigona costata (3.8%), Venustaconcha ellipsiformis ellipsiformis (3.8%), and Lampsilis teres teres (3.6%) (Table 3). These species were found at 9, 9, 7, 9, 2, 6, 8, and 5 sites, respectively, of the nine sites sampled (based on all material found). No rare or endangered naiades were found in Tavern Creek.

Maries River

Twenty-six species of naiades were found in the Maries River (Table 2). Eight species, Strophitus undulatus undulatus, Megalonaias nervosa, Quadrula

quadrula, Obliquaria reflexa, Actinonaias ligamentina carinata, Truncilla truncata, Potamilus ohiensis, and Lampsilis reeviana brittsi, had not previously been reported in the Maries River.

Eight species comprised 92.9% of the living naiades found in the Maries River: Amblema plicata plicata (39.3%), Lampsilis radiata luteola (23.7%), Lampsilis ventricosa (9.4%), Anodonta grandis grandis (6.3%), Elliptio dilatata (5.9%), Venustaconcha ellipsiformis ellipsiformis (3.5%), Potamilus alatus (2.4%), and Lampsilis teres teres (2.4%) (Table 3). These species were found at 9, 10, 8, 8, 5, 8, 9, and 7 sites, respectively, of the 11 sites sampled (based on all material found). No rare or endangered naiades were found in the Maries River.

Naiad collecting at commercial gravel dredging operations

No living naiades were found in dredged areas of the Osage River at Ozark Sand Co., Osage Sand and Gravel, and Roweth Sand and Gravel Co., based on both qualitative and quantitative sampling. Limited quadrat sampling at three undredged sites (0-15, 0-19, and 0-20) revealed densities of 4.29, 1.03, and 2.38 living naiades per square yard, respectively. The results of collecting in undredged areas at each dredging operation are discussed below.

Ozark Sand Co.

Twenty species of naiades were found in undredged areas adjacent to and below Ozark Sand Co. (Site 0-1). Live specimens of 14 species of naiades were collected at this site; 452 live naiades were examined. Subfossil specimens of Lampsilis orbiculata and Obovaria olivaria were found at this site. No living L. orbiculata were found. Continued gravel dredging at this site is unlikely to further adversely impact L. orbiculata, since no living L. orbiculata were found in this reach of the river.

Osage Sand and Gravel

Twenty-two species of naiades were found in undredged areas adjacent to and below Osage Sand and Gravel (Site 0-5). Live specimens of 21 species of naiades were collected at this site; 2,258 live naiades were examined. Most of these naiades were collected from a bed beginning approximately 500 yds. downstream from the dredging operation. Live specimens of L. orbiculata were found in this naiad bed. Continued gravel dredging in areas previously dredged at this site is unlikely to adversely impact L. orbiculata further if the river configuration is not altered. Dredging should not be permitted any further downstream.

Roweth Sand and Gravel Co.

Twenty-four species of naiades were found in undredged areas adjacent to and below Roweth Sand and Gravel Co. (Site 0-18). Live specimens of 22 species of naiades were collected at this site; 1,068 live naiades were examined. Most of these naiades were collected from a bed beginning approximately 600 yds. downstream from the dredging operation. Live specimens of L. orbiculata and Elliptio crassidens crassidens were found in this naiad bed. Subfossil specimens of O. olivaria were also found in this vicinity. Continued gravel dredging in areas previously dredged at this site is unlikely to adversely impact L. orbiculata further if the river configuration is not altered. Dredging should not be permitted any further downstream.

Naiad collecting at other dredging sites

Two other active dredging sites at Lynn Island (river mile 46.0 left bank) and at Bruemmer's Island (river mile 17.5 left bank), two inactive dredging sites, at river mile 23.9 (left bank) and at river mile 5.0 to 10.0 (main channel), and one site at which dredging is proposed, at river mile 12.1 to 12.7 (right bank), were examined on the lower Osage River. The results of naiad collecting at each of these sites are described below.

Cole County Highway Department - River Mile 46.0 (left bank)

Twenty-two species of naiades were found along the right side and below Lynn Island (Site 0-10), including shell material of Lampsilis orbiculata. No living L. orbiculata were found. Instream dredging at this site may adversely impact L. orbiculata. Floodplain dredging at this site is unlikely to adversely impact L. orbiculata provided the river configuration is not altered.

Cole County Highway Department - River Mile 23.9 (left bank)

Twenty-four species of naiades were found along the left side and below an unnamed island at river mile 23.7 (Buchanan et al. unpublished data and Site 0-16), including shell material of L. orbiculata. No living L. orbiculata were found. Instream dredging at this site may adversely impact L. orbiculata. Floodplain dredging at this site is unlikely to adversely impact L. orbiculata provided the river configuration is not altered.

Cole County Highway Department - River Mile 17.5 (left bank)

Twenty-one species of naiades were found along the right side of Bruemmer's Island (Site 0-19), including live specimens of L. orbiculata and shell material of O. olivaria. Instream dredging at this site would adversely impact L. orbiculata. Floodplain dredging at this site is unlikely to adversely impact L. orbiculata provided the river configuration is not altered.

Henry Siegler - River Mile 12.1 to 12.7 (right bank)

Twenty-one species of naiades were found at river mile 12.1 (Buchanan et al. unpublished data) and 25 species of naiades were found at river mile 13.6 (Site 0-20). Shell material of L. orbiculata, Cumberlandia monodonta, and E. c. crassidens was found at river mile 12.1. Live naiades were not sampled at this site. Live specimens of L. orbiculata and C. monodonta and shell material of A. confragosus were found at river mile 13.6. Instream dredging between river mile 12.1 and 12.7 would likely have an adverse impact on L. orbiculata and C. monodonta. Floodplain dredging at this site is unlikely to adversely impact L. orbiculata and C. monodonta provided the river configuration is not altered.

Callaway County Sand Company - River Mile 5.0 to 10.0 (main channel)

Twenty-four species of naiades were found at river mile 5.6 (Site 0-22) and 22 species of naiades were found at river mile 10.3 (Site 0-21). Shell material of L. orbiculata was found at these sites. No living L. orbiculata were found. Live specimens of Anodonta grandis corpulenta were found at both sites and shell material of Arcidens confragosus was found at river mile 10.3.

Instream dredging between river miles 5.0 and 10.0 may adversely impact L. orbiculata.

River turbidity and depth at commercial gravel dredging operations

Ozark Sand Co.

Turbidity was monitored on three operating days, 24 June, 2 October, and 4 November 1980, at Ozark Sand Co. Turbidity was significantly higher ($p \leq 0.05$; two sample t-test) during operation than before operation at stations 250 ft. upstream and 250 ft., 800 ft., and 3,700 ft. downstream from the dredging site (Fig. 7, Table 4). No significant differences ($p \geq 0.05$) in turbidity before and during operation was found at stations 4,800 ft. and 7,200 ft. downstream. Turbidity was shown to be significantly higher during operation at the station 250 ft. upstream from the dredging site, but the average turbidity changed very little (4.0 JTU's before operation vs. 5.4 JTU's during operation) (Table 4). Turbidity of wash water, sampled before it entered the river, averaged 5,700 JTU's and ranged from 670 to 11,500 JTU's.

Turbidity during operation was significantly higher ($t=3.77$, $p < 0.001$, $df=103$; paired t-test) along the left shore than along the right shore downstream from the dredging site. Turbidity averaged 24.9 JTU's (5.3 JTU's 250 ft. upstream from the dredging site) along the left shore and 8.3 JTU's (5.5 JTU's 250 ft. upstream from the dredging site) along the right shore. The dredging equipment (mechanical) and discharge (wash water) are located on the left shore (Fig. 4).

Turbidity during operation was significantly higher ($t=3.10$, $p=0.001$, $df=103$; paired t-test) at the bottom than at the surface downstream from the dredging site. Turbidity averaged 10.8 JTU's at the surface and 22.4 JTU's at the bottom. Average turbidities 250 ft. upstream from the dredging site were 5.0 JTU's at the surface and 5.7 JTU's at the bottom.

Soundings (on 3 and 4 December 1980) and SCUBA diving at Ozark Sand Co. revealed that dredging has left a trench-like excavation along much of the left shore. Generally, this excavation extends from mid-channel to the left shore and from the present dredging location to the processing site (Fig. 4). An aerial photograph taken in 1967 by the Agricultural Stabilization and Conservation Service, United States Department of Agriculture, shows a gravel bar along this left shore. Recorded depths were usually greater than 15 ft. above Highway 54 and greater than 20 ft. below. The Osage River above, below, and along the right shore at Ozark Sand Co. rarely exceeds 15 ft. in depth and is usually less than 10 ft.

Osage Sand and Gravel

Turbidity was monitored on four operating days, 13 August, 18 November, 2 December, and 11 December, 1980, at Osage Sand and Gravel. Unpredictable and sporadic operation of this firm made monitoring difficult. Turbidity was significantly higher ($p \leq 0.01$; two sample t-test) during operation than before operation at the station 1,350 ft. downstream from the dredging site, although average turbidity did not increase greatly at downstream stations during operation (Fig. 8, Table 5). Significant differences in turbidity did not occur 250 ft. downstream from the dredging site, although average turbidity during operation was highest at this station (Table 5). Turbidity of water returned to the river from the dredging operation averaged 2,800 JTU's, and ranged from 120 to 11,600 JTU's.

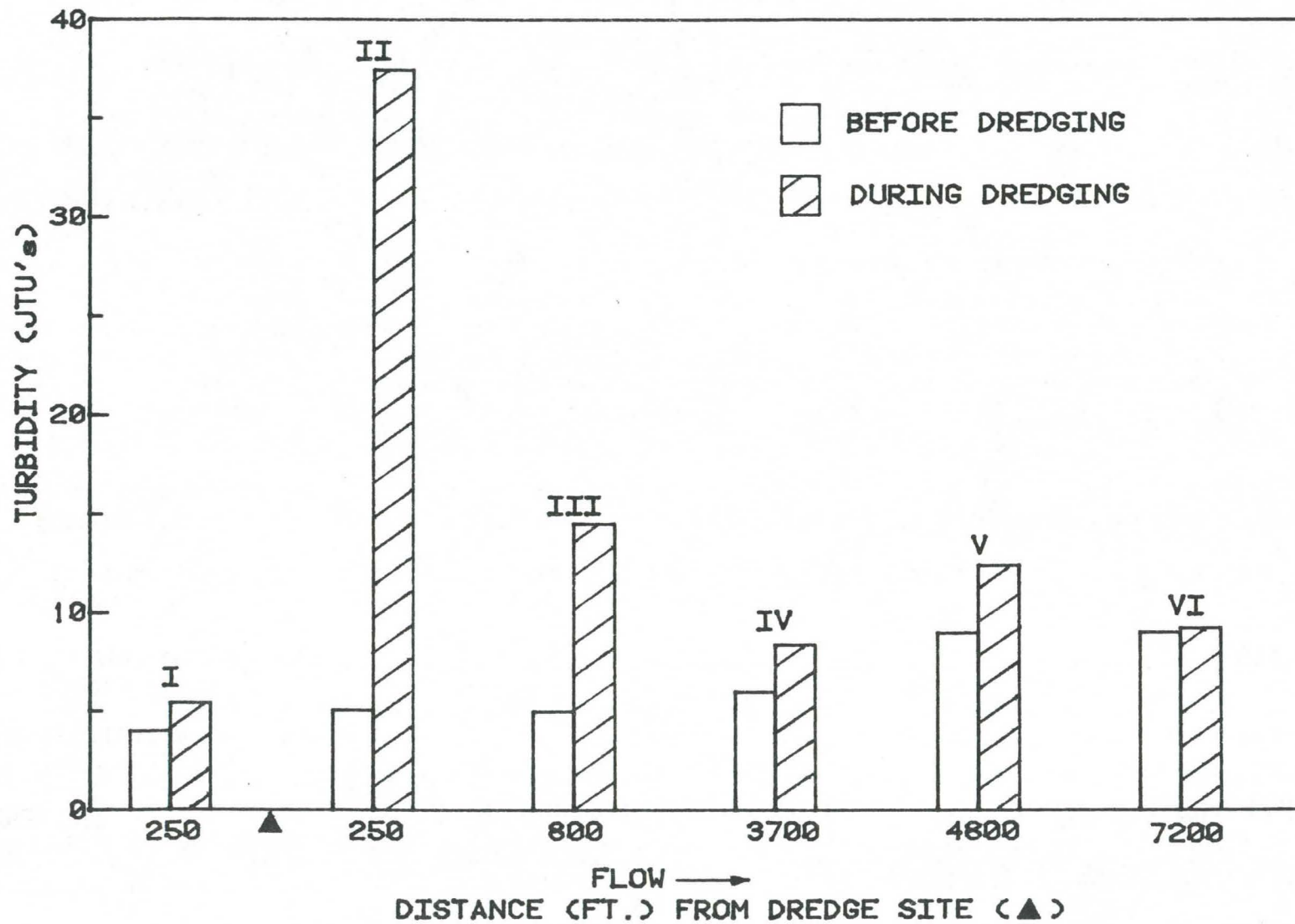


Figure 7. Turbidity (3 day mean in JTU's) at Station I upstream and Stations II - VI downstream from gravel dredging activities at Ozark Sand Co.

Table 4. Statistical comparison of turbidity in water samples collected before and during dredging activities at Ozark Sand Co. on 24 June, 2 October, and 4 November 1980.

Station (location)	Turbidity (JTU's)		Before operation vs. During operation ^a		
	Before operation Mean \pm SD	During operation Mean \pm SD	t-value	Degrees of freedom (df)	Level of significance (p)
Station I (250 ft. upstream ^b)	4.0 \pm 1.9	5.4 \pm 2.0	-2.29	58	0.013
Station II (250 ft. downstream)	5.1 \pm 2.0	37.5 \pm 67.1	-1.92	58	0.030
Station III (800 ft. downstream)	5.0 \pm 1.7	14.5 \pm 10.6	-3.55	58	<0.001
Station IV (3,700 ft. downstream)	6.0 \pm 1.6	8.4 \pm 4.8	-1.94	58	0.029
Station V (4,800 ft. downstream)	9.0 \pm 3.8	12.4 \pm 10.4	-1.09	42	0.142
Station VI (7,200 ft. downstream)	9.0 \pm 2.0	9.2 \pm 2.8	-0.30	58	0.384

^aTwo sample t-test.

^bDistance and direction from dredging site.

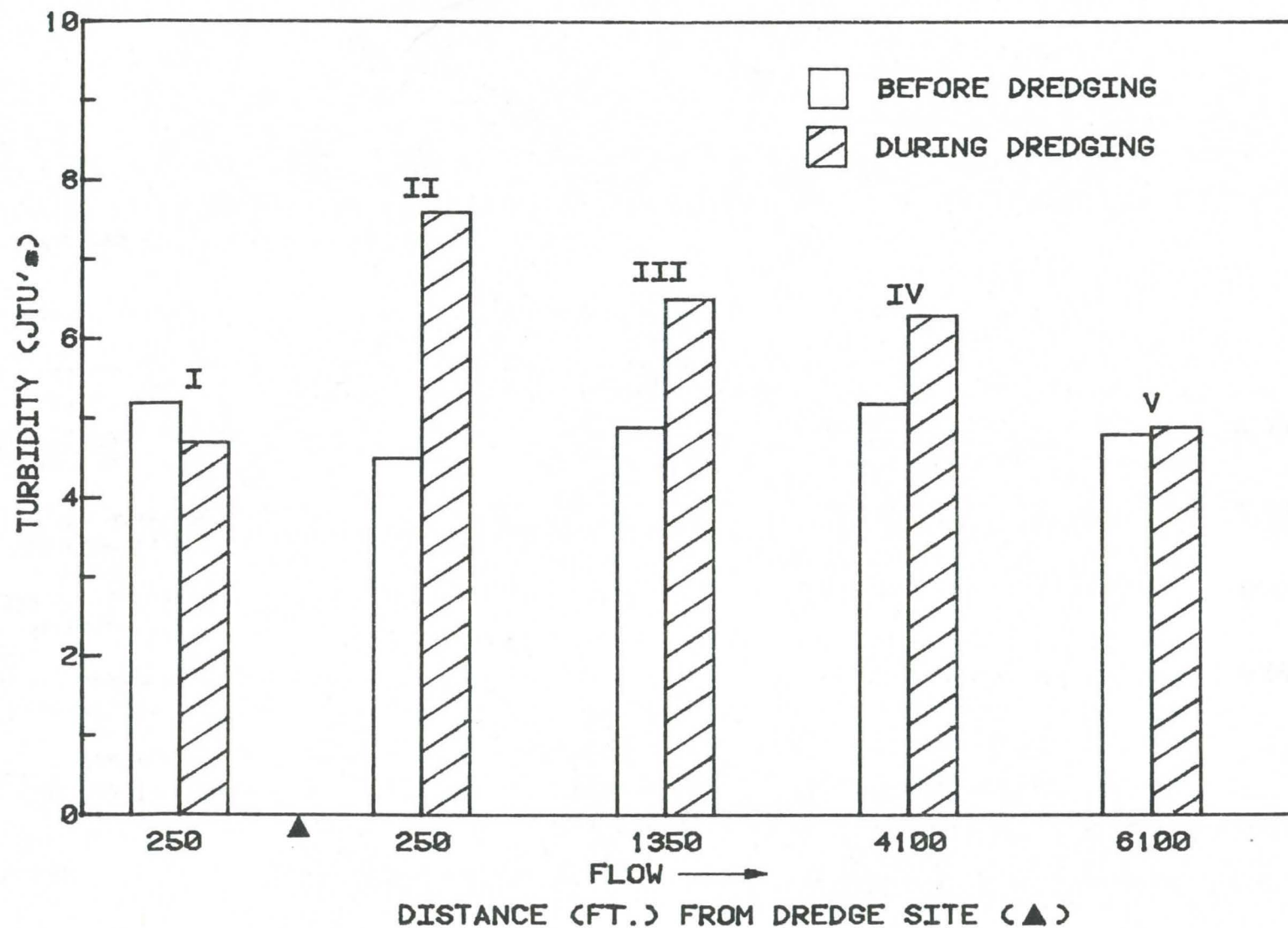


Figure 8. Turbidity (4 day mean in JTU's) at Station I upstream and Stations II - V downstream from gravel dredging activities at Osage Sand and Gravel Co.

Table 5. Statistical comparison of turbidity in water samples collected before and during dredging activities at Osage Sand and Gravel on 13 August, 18 November, 2 December, and 11 December 1980.

Station (location)	Turbidity JTU's)		Before operation vs. During operation ^a		
	Before operation Mean \pm SD	During operation Mean \pm SD	t-value	Degrees of freedom (df)	Level of significance (p)
Station I (250 ft. upstream ^b)	5.2 \pm 1.7	4.7 \pm 1.8	1.09	54	0.141
Station II (250 ft. downstream)	4.5 \pm 0.8	7.6 \pm 6.9	-1.55	30	0.066
Station III (1,350 ft. downstream)	4.9 \pm 1.4	6.5 \pm 2.9	-2.41	54	0.010
Station IV (4,100 ft. downstream)	5.2 \pm 2.2	6.3 \pm 3.6	-1.26	54	0.106
Station V (6,100 ft. downstream)	4.8 \pm 1.2	4.9 \pm 1.5	-0.30	54	0.382

^aTwo sample t-test.

^bDistance and direction from dredging site.

There was no significant difference ($p>0.05$; paired t-test) in turbidity between samples collected along the left shore and the right shore during operation downstream from the dredging site. Turbidity averaged 6.3 JTU's (5.0 JTU's 250 ft. upstream from the dredging site) along the left shore and 6.1 JTU's (4.3 JTU's 250 ft. upstream from the dredging site) along the right shore. The dredging equipment (hydraulic) is located in the main channel; water used during dredging and washing operations is returned to the river at two points along the left shore (Fig. 5).

Turbidity during operation was significantly higher ($t=3.16$, $p=0.001$, $df=63$; paired t-test) at the bottom than at the surface downstream from the dredging site. Turbidity averaged 5.4 JTU's at the surface and 7.0 JTU's at the bottom. Average turbidities 250 ft. upstream from the dredging site were 4.5 JTU's at the surface and 4.8 JTU's at the bottom.

Soundings (on 11 December 1980) and SCUBA diving at Osage Sand and Gravel revealed that dredging has created an irregular bottom (troughs) with depths up to 25 ft. Generally, the area dredged is adjacent to the on-shore operation (Fig. 5). Deep excavations extend across the river near an abandoned Sauerman dredge and from mid-channel to the left shore upstream from this area. Extensive gravel bars and riffles occur above and below Osage Sand and Gravel; river depths rarely exceed 3 ft. above and 10 ft. below.

Roweth Sand and Gravel Co.

Turbidity was monitored on three operating days, 25 September, 9 October, and 13 November 1980, at Roweth Sand and Gravel Co. Turbidity was significantly higher ($p\leq 0.01$; two sample t-test) during operation than before operation 250 ft. downstream from the dredging site (Fig. 9, Table 6). No significant difference ($p>0.05$) in turbidity before and during operation was found at stations 250 ft. upstream and 1,150 ft., 3,300 ft., and 5,400 ft. downstream from the dredging site. Water samples were collected from an area that had been dredged in the past at the station 250 ft. upstream from the dredging site. Bottom samples were collected in water up to 53 ft. deep. The high average turbidity at this station (Table 6) is believed to have been caused by sediments still in suspension and perhaps mixing of turbid water from the downstream dredging activities. Turbidity of wash water averaged 3,700 JTU's, and ranged from 130 to 9,100 JTU's.

Turbidity during operation was significantly higher along the left shore than along the right shore, both upstream ($t=2.60$, $p=0.008$, $df=23$; paired t-test) and downstream ($t=7.12$, $p<0.001$, $df=63$; paired t-test) from the present dredging site. Turbidity averaged 13.3 JTU's upstream and 8.1 JTU's downstream from the dredging site along the left shore and 8.0 JTU's upstream and 5.3 JTU's downstream from the dredging site along the right shore. The dredging equipment (mechanical) and discharge (wash water) are located on the left shore (Fig. 6).

Turbidity during operation was significantly higher at the bottom than at the surface upstream ($t=5.74$, $p<0.001$, $df=23$; paired t-test) and downstream ($t=2.80$, $p=0.003$, $df=75$; paired t-test) from the present dredging site. Turbidity averaged 4.6 JTU's upstream and 6.8 JTU's downstream from the dredging site at the surface and 16.6 JTU's upstream and 7.6 JTU's downstream from the dredging site at the bottom.

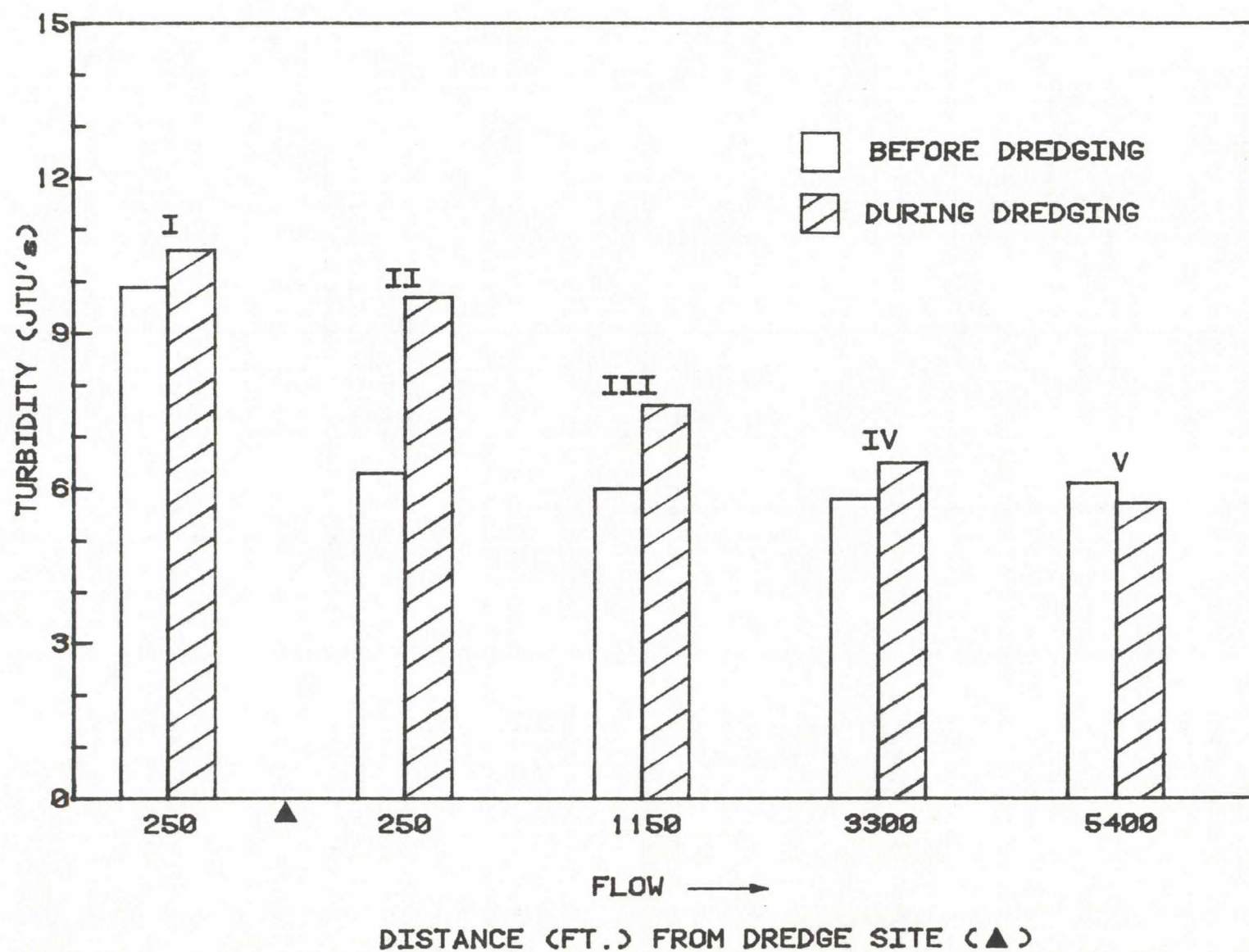


Figure 9. Turbidity (3 day mean in JTU's) at Station I upstream and Stations II - V downstream from gravel dredging activities at Roweth Sand and Gravel Co.

Table 6. Statistical comparison of turbidity in water samples collected before and during dredging activities at Roweth Sand and Gravel Co. on 25 September, 9 October, and 13 November 1980.

Station (location)	Turbidity (JTU's)		Before operation vs. During operation ^a		
	Before operation Mean \pm SD	During operation Mean \pm SD	t-value	Degrees of freedom (df)	Level of significance (p)
Station I (250 ft. upstream ^b)	9.9 \pm 8.1	10.6 \pm 9.5	-0.24	58	0.405
Station II (250 ft. downstream)	6.3 \pm 1.7	9.7 \pm 3.0	-2.65	28	0.007
Station III (1,150 ft. downstream)	6.0 \pm 1.9	7.6 \pm 4.5	-1.16	58	0.125
Station IV (3,300 ft. downstream)	5.8 \pm 1.8	6.5 \pm 2.4	-0.91	58	0.183
Station V (5,400 ft. downstream)	6.1 \pm 2.7	5.7 \pm 2.4	0.34	38	0.369

^aTwo sample t-test.

^bDistance and direction from dredging site.

Soundings (on 5 December 1980) and SCUBA diving at Roweth Sand and Gravel Co. revealed that dredging has left an extensive, extremely deep (up to 60 ft.) area adjacent to the on-shore operation (Fig. 6). This unusually steep-sided excavation extends from the main channel border area near the right shore to the left shore. Gravel islands occur above and below this operation dredged area. River depths immediately above and below this rarely exceed 10 ft.

SPECIES PROFILES

This section provides a description of the status, shell characters, distribution, both in Missouri and in North America, habitat preference, relative abundance, breeding season, fish hosts, and economic value of the species of naiades that were found in the lower Osage River, Tavern Creek, and Maries River during this study and in previous studies. Information on status, shell characters, breeding season, fish hosts, and economic value of each species was obtained from published reports. The habitat preference and distribution of each species is based on information taken from published reports and data collected during this study. Water quality information measured at each collection site is listed in Appendix C. The fish hosts listed are the known or suspected host(s) for the glochidia of each naiad species. The fish host(s) for many naiades are not known. Taxonomic names used are those determined to be correct by Dr. David H. Stansbery of Ohio State University.

Lampsilis orbiculata, listed as endangered on the United States List of Endangered and Threatened Wildlife and Plants (United States Department of the Interior, Fish and Wildlife Service 1976), and Cumberlandia monodonta, under Notice of Review for possible addition to the above list, are the first and second species, respectively, presented in this section. The remaining species are arranged in phylogenetic order. An introduced species of clam, Corbicula leana, is the last species treated.

Lampsilis orbiculata (Hildreth 1828)

Pink Mucket Pearly Mussel

Status: Endangered in the United States (United States Department of the Interior, Fish and Wildlife Service 1976).

Physical Description (Ortmann 1919): The shells are extremely thick and heavy and subelliptical or subovate. Anterior margin is rounded. Ventral margin is convex. Males are sharply-rounded posteriorly; the females are truncated posteriorly. Beaks are moderately swollen, only slightly elevated above the hinge line, turned forward and located in the anterior half of the shell. Beak sculpture is obsolete. Epidermis is light yellowish-brown to brown. Rays are absent except in young specimens. Cardinal teeth are variable in shape, but strong, stumpy and ragged. Lateral teeth are thick and heavy, moderately long and slightly curved. Beak cavities are moderately deep. The nacre is white to salmon, and commonly is salmon to orange in the beak cavities even if white elsewhere. Adults commonly 2 to 4 inches long.

Geographic Distribution: L. orbiculata was found from Bagnell Dam to river mile 5.6 in the lower Osage River (Fig. 10). Living specimens were found at nine sites between river miles 13.6 and 66.0. None were found in the Maries River or Tavern Creek. The L. orbiculata found in the lower Osage River ranged from 8 to over 20 years of age. In Missouri, L. orbiculata has been reported from the Meramec and Big rivers (Buchanan 1980), Little Black River (Buchanan 1979), and St. Francis, Black, Sac and Gasconade rivers (Oesch in press). In North America, L. orbiculata is known from the Ohio River Basin, Tennessee River Basin, and lower Mississippi River Basin (Stansbery unpublished data).

Habitat: L. orbiculata was found in a range of substrates from silt to cobble but was most commonly found in a gravel and cobble substrate. It was found in 1 to 10 feet of water in slow (less than 0.2 ft./sec. at the bottom) to moderate (1.4 ft./sec. at the bottom) current. Buchanan (1980) found it in a similar habitat in the Meramec River.

Relative Abundance: L. orbiculata comprised only 0.1% of the living naiades found in the lower Osage River Basin (Table 3). Buchanan (1980) found similar densities of this species in the Meramec River Basin. Based on available literature this species is uncommon throughout its range.

Breeding Season: Bradytictic (Ortmann 1919).

Fish Host: Unknown.

Commercial Value: None.

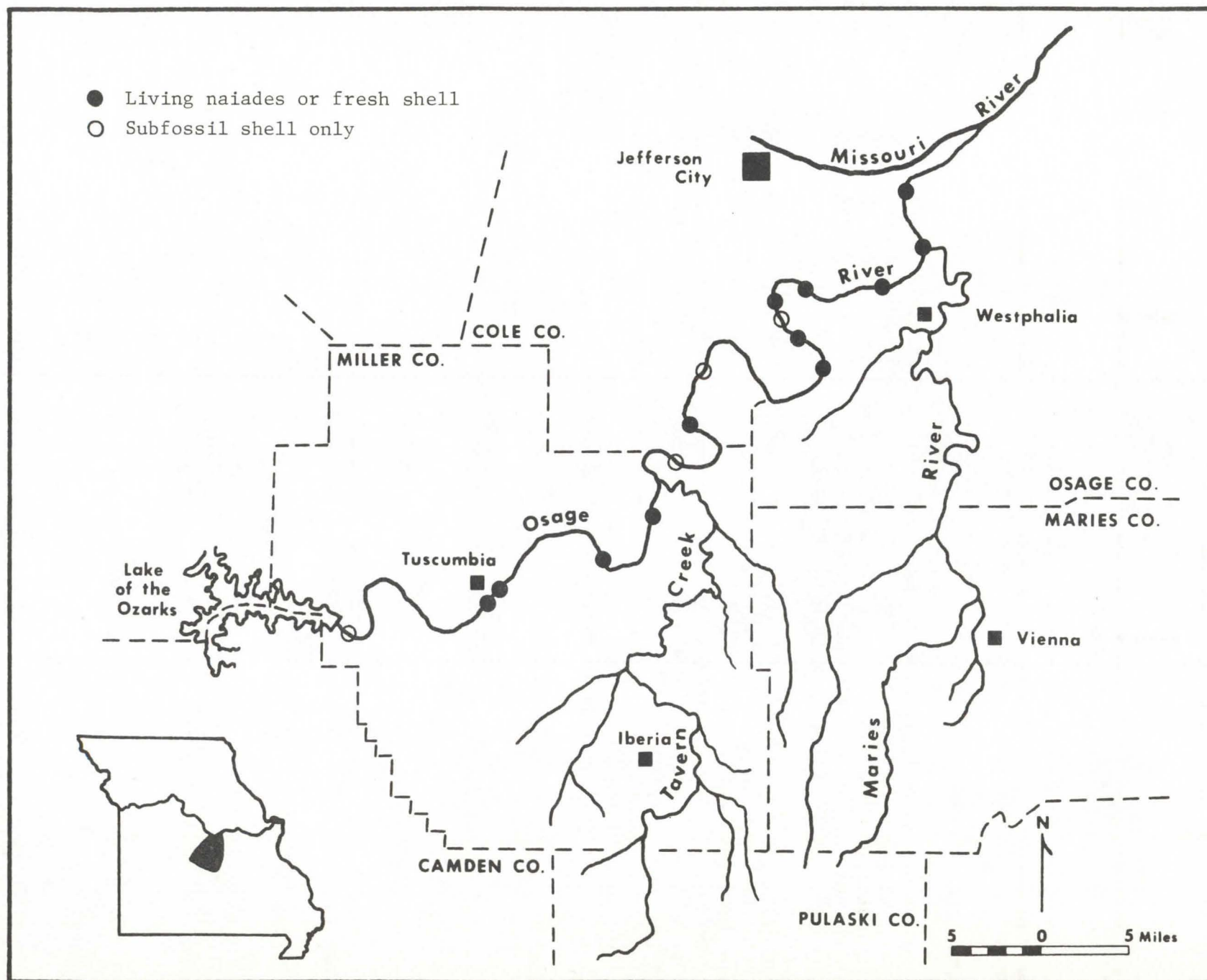


Figure 10. Distribution of *Lampsilis orbiculata* (Hildreth 1828) in the lower Osage River, Tavern Creek, and Maries River.

Cumberlandia monodonta (Say 1829)

Spectacle Case

Status: Rare throughout its range and in Missouri (Missouri Department of Conservation 1977). Under Notice of Review for possible addition to the U. S. List of Endangered and Threatened Wildlife and Plants (United States Department of the Interior, Fish and Wildlife Service 1976).

Physical Description (Utterback 1915; Baker 1928): The shells are narrowly elliptical, compressed, and unsculptured. Beaks are only slightly elevated above the hinge line and the beak sculpture consists of heavy ridges parallel to growth lines. Epidermis is generally dark brown or black. Nacre is pearl blue to white. Anterior cardinal teeth are lacking; the posterior ones are conical. Lateral teeth are reduced or lacking. Beak cavities are shallow. Adults commonly 3 to 9 inches long.

Geographic Distribution: C. monodonta was found at eight sites between river miles 13.6 and 65.0 in the lower Osage River (Fig. 11). None were found in Tavern Creek or the Maries River. In the past, Utterback (1917) found this species in the Mississippi River, northwest Missouri lakes, and in the Osage and Platte River basins. More recently, it has been reported from the Meramec, Bourbeuse, Big, and Sac rivers (Buchanan 1980), the Gasconade and Salt rivers and the River Aux Vases (Oesch 1974), and the Big Piney River (unpublished data). In North America, it is known from the Cumberland and Tennessee river systems, and from Ohio, Illinois, Indiana, and Nebraska (Burch 1973), and from the Mississippi River (Fuller 1978).

Habitat: This species was found in a silt to boulder substrate but was usually collected in a cobble to boulder substrate. It was found in 18 inches to 18 feet of water in slow (less than 0.2 ft./sec. to 0.6 ft./sec. at bottom) current. Buchanan (1980), during a survey of the Meramec River Basin, found this species in a gravel and cobble, or boulder substrate, in slow current (less than 0.2 to 0.6 ft./sec. at the bottom) off the main current, in 1 inch to 3.5 feet of water. Most commonly he found many individuals wedged between rocks entirely out of the current. Parmalee (1967) found this species in a gravel to sand substrate in moderate to swift current in medium-sized to large rivers in Illinois. Stansbery (1973) stated that C. monodonta was commonly found near swift current deeply imbedded in fine sand, firm mud, in vegetation, or between rocks.

Relative Abundance: C. monodonta comprised 0.2% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 2.2% of the living naiades in the Meramec River Basin (Buchanan 1980). It is common in the Gasconade River (Oesch in press) but is uncommon in Illinois (Parmalee 1967), Indiana (Goodrich and van der Schalie 1944), and the Mississippi River (Fuller 1978).

Breeding Season: Bradytictic (Baker 1928).

Fish Host: Unknown.

Commercial Value: None.

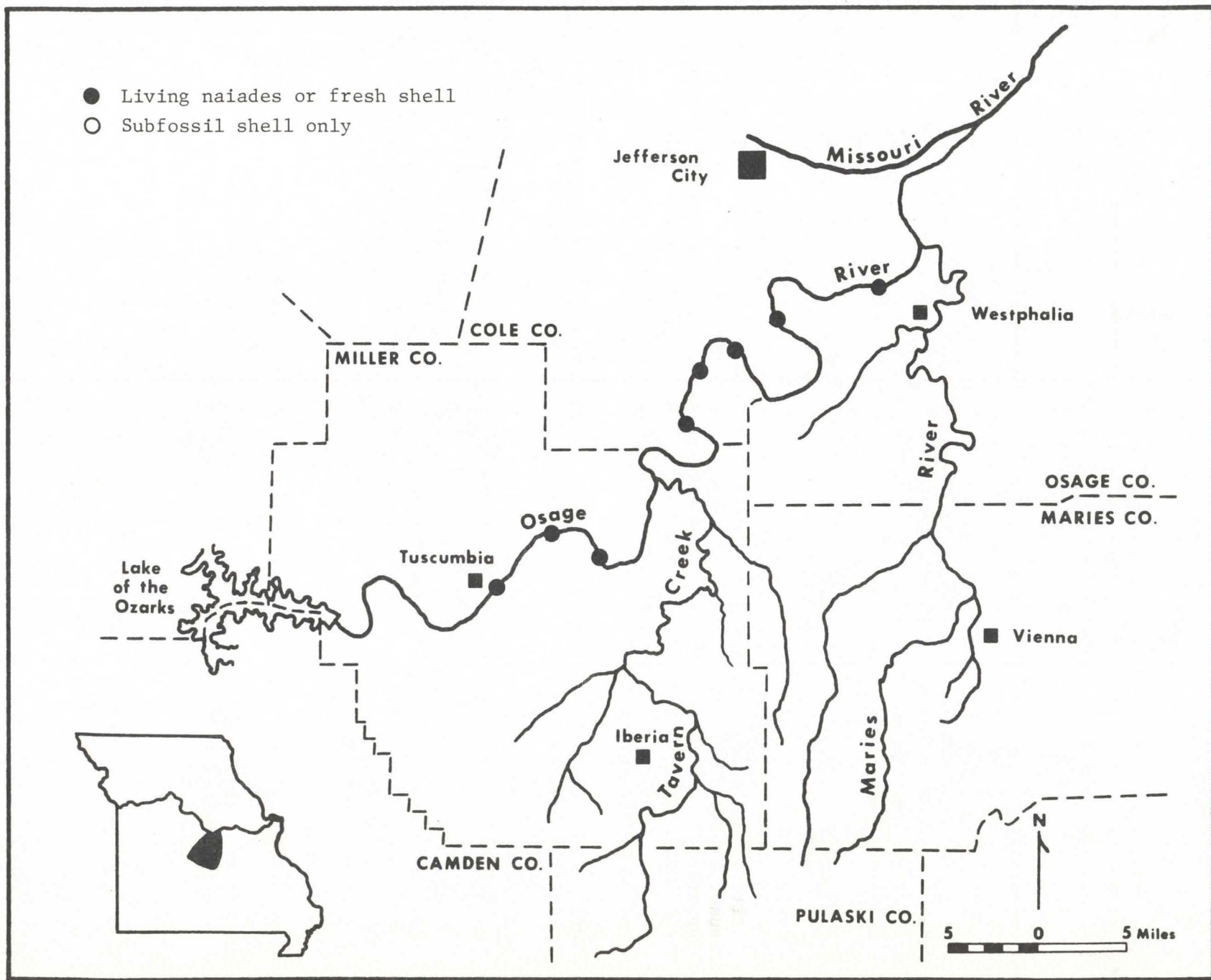


Figure 11. Distribution of Cumberlandia monodonta (Say 1829) in the lower Osage River, Tavern Creek, and Maries River.

Anodonta imbecillis (Say 1829)

Paper Pond Shell

Status: Unclassified.

Physical Description (Utterback 1915; Parmalee 1967): The shells are sub-elliptical, thin, inflated and slightly alate. Hinge line is nearly straight. Beaks are flattened, usually flush with the hinge line, and have five to six fine, irregular double-looped, concentric ridges. Epidermis is glossy and yellowish or greenish with numerous fine rays. Hinge teeth are lacking. Nacre is bluish-white. Beak cavities wide and shallow. Adults commonly 1 to 4 inches long.

Geographic Distribution: A. imbecillis was found at only a single site each in the lower Osage and Tavern Creek, and at three sites in the downstream half of the Maries River (Fig. 12). Only seven living specimens were found. In the past Utterback (1915; 1917) found this species in Spring, Mud, and Lower lakes, the Mississippi River, the Osage, Blackwater, and White river basins, and in northwest Missouri lakes. More recently it has been reported from the Meramec River Basin (Buchanan 1980), the St. Francis, Salt, Sac, Current, James, Marmaton, and Loutre rivers and in Sandy Creek (Oesch in press), and in the Little Black River (Buchanan 1979). A. imbecillis is known from the Ohio-Mississippi River system, the Gulf of Mexico drainage from Florida to Mexico, the Atlantic drainage from North Carolina to Georgia, and the Great Lakes system from Wisconsin to Central New York (Clarke and Berg 1959).

Habitat: A. imbecillis was found in silt, sand, or gravel substrate, in 3 inches to 2.5 feet of water, in standing water. Buchanan (1979; 1980) found this species in a silt, silt and sand, or gravel and cobble substrate, in 1 inch to 3.5 feet of water, in slow current in the Meramec and Little Black river basins. Other authors (Murray and Leonard 1962; Parmalee 1967; and Goodrich and van der Schalie 1944) found that this species inhabits sand or mud bottoms in quiet water in lakes, ponds, river-lakes, small streams, and medium-sized to large rivers.

Relative Abundance: A. imbecillis comprised less than 0.1% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 1.1% of the living naiades found in the Meramec River Basin (Buchanan 1980) and 0.2% of the living naiades found in the Little Black River Basin (Buchanan 1979). A. imbecillis is a relatively common species in Illinois (Parmalee 1967), Indiana (Goodrich and van der Schalie 1944), and Minnesota (Dawley 1947).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Creek chub, Semotilus atromaculatus and green sunfish, Lepomis cyanellus (Fuller 1978).

Commercial Value: None.

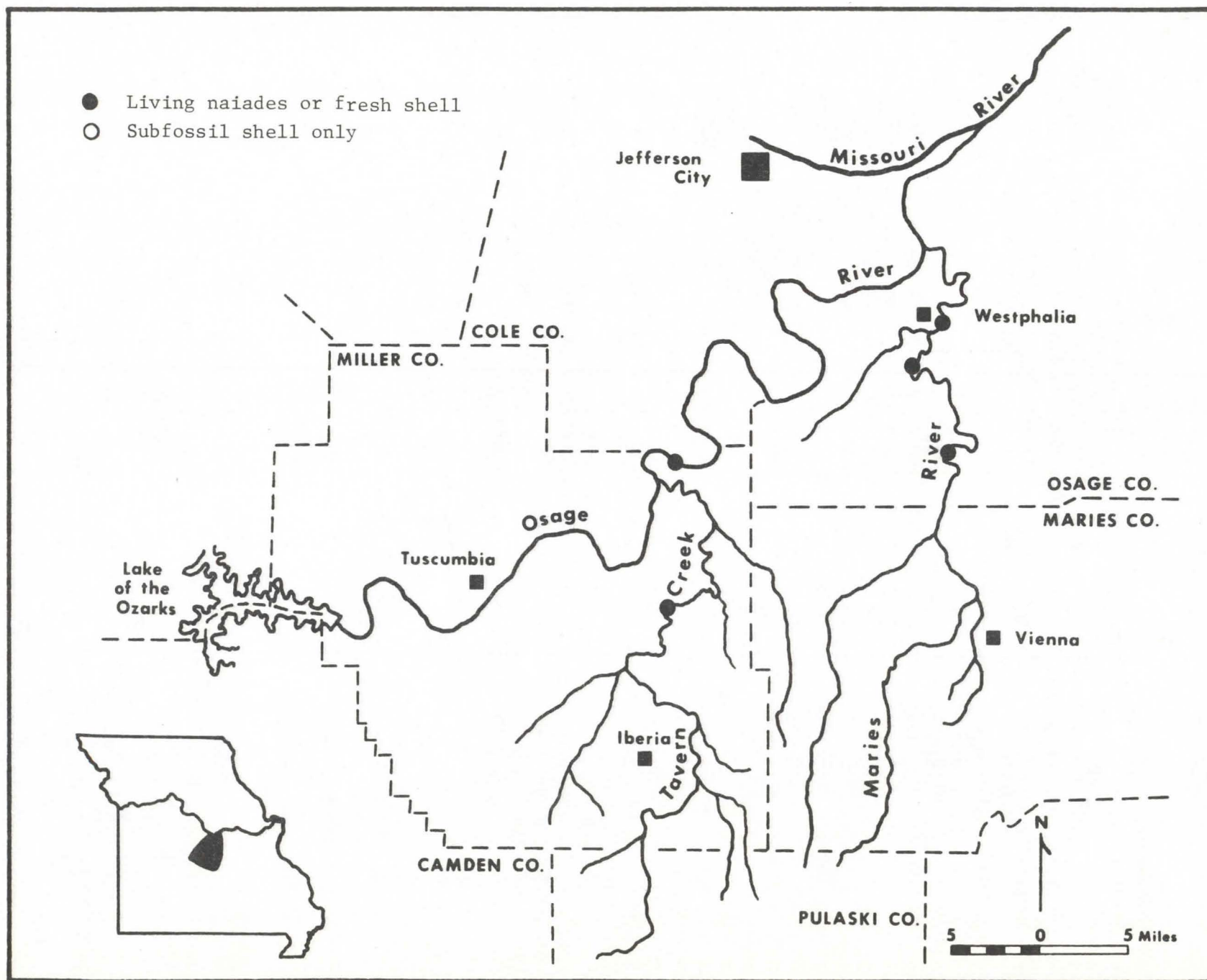


Figure 12. Distribution of *Anodonta imbecillis* (Say 1829) in the lower Osage River, Tavern Creek, and Maries River.

Anodonta grandis grandis (Say 1829)

Floater

Status: Unclassified.

Physical Description (Ortmann 1919; Baker 1928): The shells are subovate, thin to moderately solid and inflated to swollen in the umbone region. Beaks are swollen and moderately elevated; the beak sculpture consists of four to five heavy bars (the first two concentric, the rest double-looped). The epidermis is glossy and green to brown. Hinge teeth are completely lacking. Beak cavities are large and deep. Nacre is bluish or salmon to white. Adults commonly 2 to 6 inches long.

Geographic Distribution: A. g. grandis was common in the lower Osage River, Tavern Creek, and the Maries River, and was locally abundant in the Maries River (Fig. 13). Utterback (1915; 1917) reported this species from Mud Lake, Lake Contrary, the Mississippi and Des Moines rivers, and from the Chariton, Grand, Platte, Tarkio, and Blackwater river basins. More recently it was found throughout the Meramec River Basin (Buchanan 1980), in the Cuivre, Salt and North Fork rivers (Duchrow 1974), the James, Elk, Spring, South Grand, Whitewater and Black rivers and Grindstone, Sandy and Auxvasse creeks (Oesch in press), and in the Little Black River Basin (Buchanan 1979). Outside of Missouri, A. g. grandis has been reported from throughout the Mississippi-Missouri River drainage, the St. Lawrence drainage, and Canadian Interior Basin from western Ontario to Alberta and in the Gulf drainages of Louisiana and Texas (Burch 1973).

Habitat: A. g. grandis occurred in an array of substrates from silt to boulder, in 2 inches to 10 feet of water, in standing (0.0 ft./sec. at the bottom) to moderately-flowing (1.4 ft./sec. at the bottom) water. It was usually found in slow to no current however. This habitat is similar to that described by Buchanan (1979; 1980) in the Meramec and Little Black river basins. Other authors (Parmalee 1967; Murray and Leonard 1962; Goodrich and van der Schalie 1944; Stansbery 1973) list a wide range of habitats for this species.

Relative Abundance: This species comprised 0.9% of the living naiades found in the lower Osage River Basin (Table 3). A. g. grandis comprised 2.5% of the living naiades found in the Meramec River Basin (Buchanan 1980) and 2.9% of the living naiades found in the Little Black River Basin (Buchanan 1979). This is a common species in Missouri (Oesch in press), Illinois (Parmalee 1967), eastern Kansas (Murray and Leonard 1962), Indiana (Goodrich and van der Schalie 1944), Minnesota (Dawley 1947), and Wisconsin (Mathiak 1979).

Breeding Season: Tachytictic (Utterback 1915).

Fish Host: Carp, Cyprinus carpio; yellow perch, Perca flavescens; bluegill, Lepomis macrochirus; rock bass, Ambloplites rupestris; white crappie, Pomoxis annularis and 17 other fish species (Fuller 1978).

Commercial Value: None.

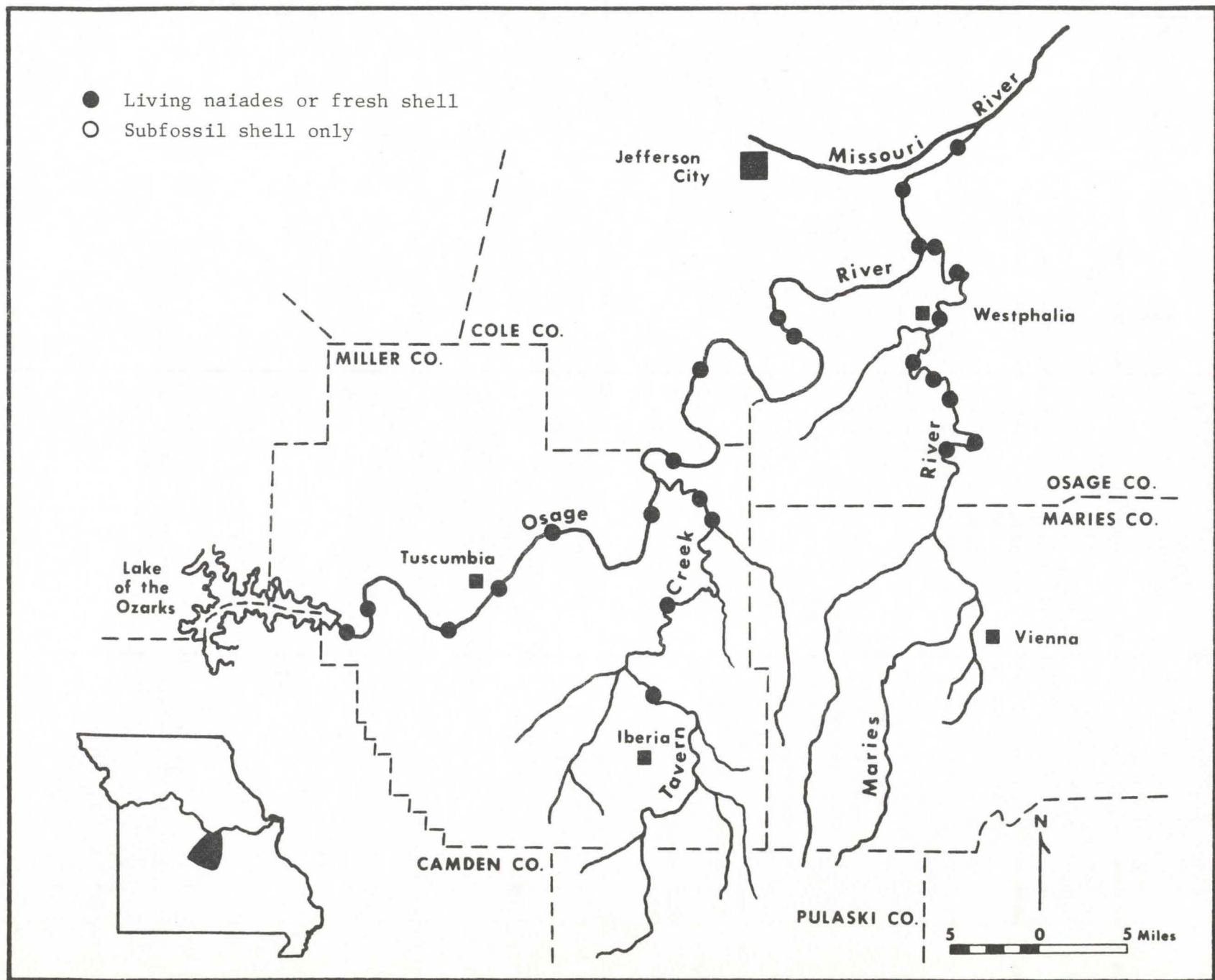


Figure 13. Distribution of Anodonta grandis grandis (Say 1829) in the lower Osage River, Tavern Creek, and Maries River.

Anodonta grandis corpulenta (Cooper 1834)

Stout Floater

Status: Endangered in Missouri (Missouri Department of Conservation 1977).

Physical Description (Baker 1928; Parmalee 1967): The shells are large, subrhomboid, thin to moderately solid, and inflated. Dorsal margin is straight. Shells are usually alate on both sides of the umbones. Beaks are full, high and elevated; beak sculpture consists of three to four irregular double-looped bars often represented only by raised nodules. Epidermis is yellowish-brown to greenish black. Hinge teeth are lacking. Beak cavities are deep and broad. Nacre is whitish, purplish, pink, or salmon. Adults commonly 2 to 7 inches long.

Geographic Distribution: A. g. corpulenta was found at only three sites between river miles 5.6 and 69.0 in the lower Osage River (Fig. 14). None were found in the Maries River or Tavern Creek. Utterback (1917) found this species only in the Mississippi River. More recently, Oesch (in press) found it in the Gasconade and Castor rivers and Sandy Creek, and Buchanan (1980) found it in the lower Meramec River. In North America, A. g. corpulenta is reported from the Mississippi River system, the Ohio River system, the Red River system, the Black River system, and the White and St. Francis rivers (Johnson 1980).

Habitat: A. g. corpulenta was found in a silt to a silt, sand, gravel, cobble, and boulder substrate in 18 inches to 10 feet of water, in standing to moderately-flowing water. Buchanan (1980) found this species in a silt substrate, in 1 inch to 2.5 feet of water, in slowly moving to standing water (less than 0.2 ft./sec. at the bottom) in the Meramec River. A. g. corpulenta generally occurs in large rivers, in a silt, sand, or mud substrate, in quiet water (Baker 1928; Parmalee 1967).

Relative Abundance: This species comprised less than 0.1% of the living naiades found in the lower Osage River Basin (Table 3). Buchanan (1980) found low numbers of this species in the Meramec River Basin. A. g. corpulenta is extremely uncommon in Missouri (Oesch in press) but is common in large rivers in Illinois (Parmalee 1967) and Minnesota (Dawley 1947).

Breeding Season: Bradytictic (Surber 1912).

Fish Host: Skipjack herring, Alosa chrysochloris (Baker 1928).

Commercial Value: None.

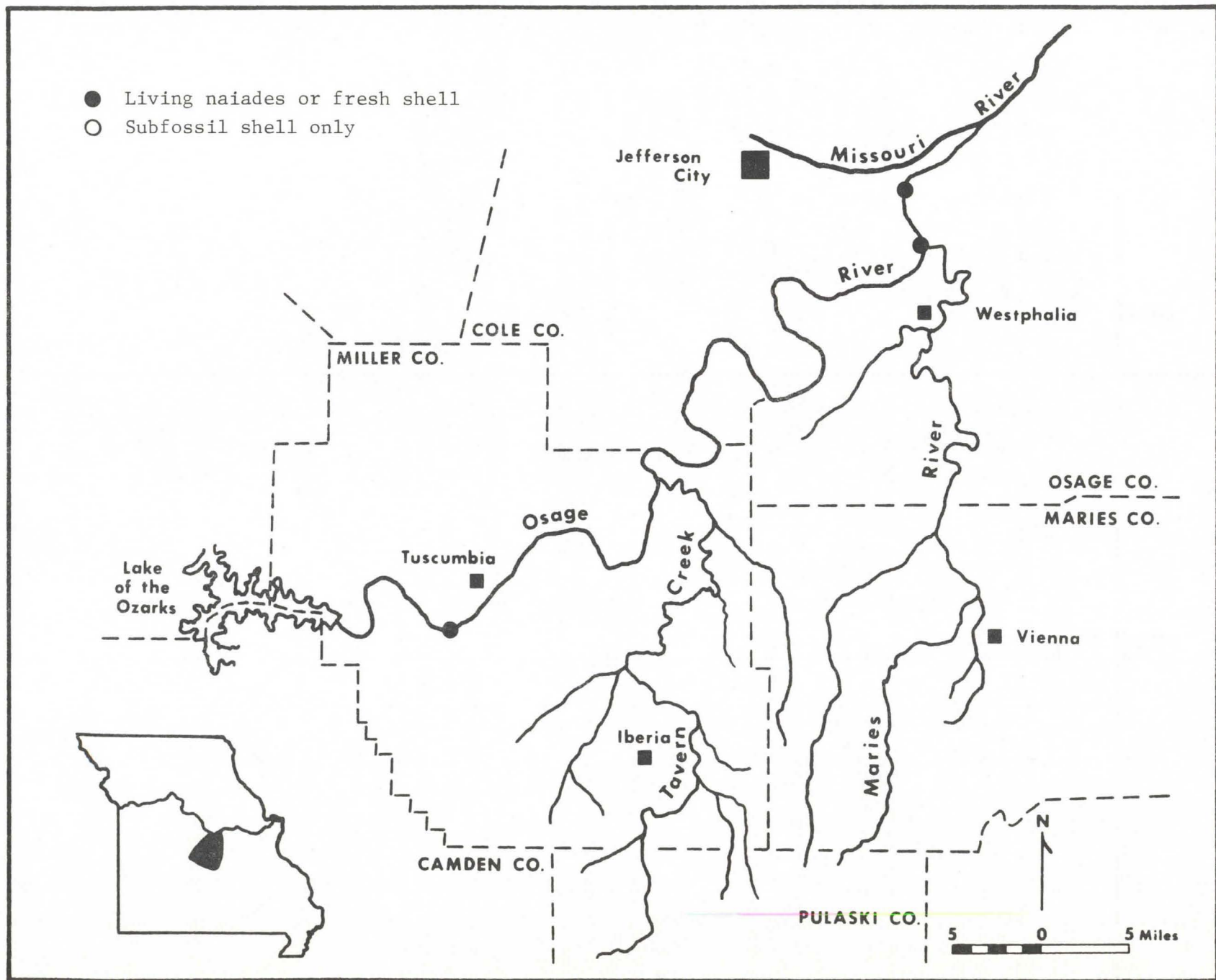


Figure 14. Distribution of Anodonta grandis corpulenta (Cooper 1834) in the lower Osage River, Tavern Creek, and Maries River.

Strophitus undulatus undulatus (Say 1817)

Squaw Foot

Status: Unclassified.

Physical Description (Utterback 1915; Parmalee 1967): The shells are elongate-ovate or elliptical, compressed in young shells and moderately inflated in old shells. Beaks are depressed; beak sculpture consists of two or three very coarse wavy concentric ridges bent upward posteriorly. Epidermis is with or without rays, yellowish to black and glossy. Cardinal teeth are mere swellings; the lateral teeth are lacking. Beak cavities are shallow. Nacre is bluish-white to white. Adults commonly 1 to 4 inches long.

Geographic Distribution: In the lower Osage River Basin, S. u. undulatus was found scattered throughout the lower Osage River, was common in the downstream 32.1 miles of the Maries River and in Tavern Creek from its headwaters to its mouth (Fig. 15). S. u. undulatus is found in all regions of Missouri, based on both past (Utterback 1917) and recent (Oesch in press) records. In North America, S. u. undulatus is found in the Mississippi and Ohio River drainages, from central Texas to Lake Winnipeg, Canada, the Atlantic drainage and the upper Savannah River tributary of South Carolina to the St. Lawrence River system (Burch 1973).

Habitat: S. u. undulatus occurred in an array of substrates from silt to cobble and boulder, in 1 inch to 8 feet of water, in standing (0.0 ft./sec. at the bottom) to moderately-flowing (1.1 ft./sec. at the bottom) water. Buchanan (1979; 1980) found S. u. undulatus in a silt to cobble substrate, in 1 inch to 3 feet of water, in standing to swiftly-flowing (2.0 ft./sec. at the bottom) water in the Meramec and Little Black river basins. Parmalee (1967) and Murray and Leonard (1962) reported this species from mud, sand or gravel bottoms in medium-sized and large rivers.

Relative Abundance: S. u. undulatus comprised only 0.1% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised only 1.7% and 0.8%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). This species is common in Missouri (Oesch in press) and surrounding states (Parmalee 1967; Murray and Leonard 1962; Goodrich and van der Schalie 1944; Dawley 1947; Mathiak 1979).

Breeding Season: Bradytictic (Baker 1928).

Fish Host: Creek chub, Semotilus atromaculatus; green sunfish, Lepomis cyanellus; largemouth bass, Micropterus salmoides; Rio Grande killifish, Fundulus zebrinus (Fuller 1978).

Commercial Value: None.

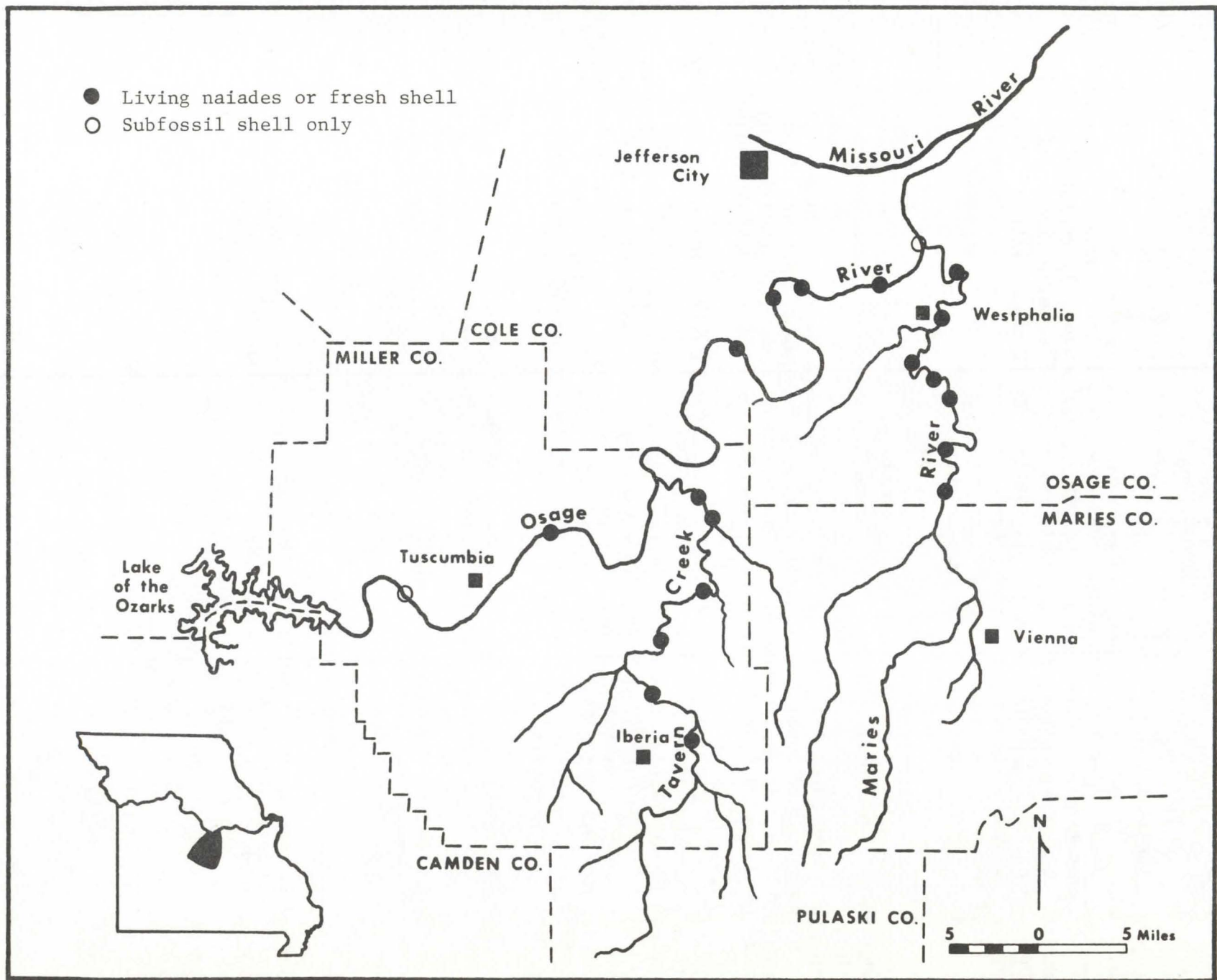


Figure 15. Distribution of Strophitus undulatus undulatus (Say 1817) in the lower Osage River, Tavern Creek, and Maries River.

Arcidens confragosus (Say 1829)

Rock Pocketbook

Status: Endangered in Missouri (Missouri Department of Conservation 1977).

Physical Description (Utterback 1915; Parmalee 1967; Baker 1928): The shells are thin to moderately solid, squarish to nearly rhomboid and inflated. Beaks are high and full and have irregular nodules or corrugations which form two loops; the corrugations break up into knobs on the disk of the shell. Irregular ridges or folds are present on the posterior third of shell. Epidermis is brown to black. Cardinal teeth are elongated and compressed. Lateral teeth are reduced and short. Nacre is white. Beak cavities are wide and moderately deep. Adults commonly 2 to 5 inches long.

Geographic Distribution: A. confragosus was found at only three sites in the lower Osage River, no living specimens were found (Fig. 16). Utterback (1917) reported this species from the Mississippi River, northwest Missouri lakes, and the Osage River Basin. More recently, it has been reported from the lower Meramec River and the Sac River (Buchanan 1980), from the Mississippi and St. Francis rivers (Oesch in press), and from the lower Little Black River (Buchanan 1979). In North America, A. confragosus is known from the Mississippi River Basin from southern Ohio west to eastern Texas and into Louisiana (Burch 1973).

Habitat: In the Meramec and Little Black rivers, A. confragosus was found in substrate types ranging from silt to cobble and boulder, in 4 inches to 3.5 feet of water, in standing to slow-moving water (less than 0.2 ft./sec. at the bottom). This species is generally restricted to medium-sized and large rivers (Parmalee 1967; Murray and Leonard 1962).

Relative Abundance: No living specimens of this species were found in the lower Osage River Basin (Table 3). A. confragosus comprised less than 0.1% of the living naiades found in both the Meramec and Little Black river basins (Buchanan 1979; 1980). This species is common in Illinois (Parmalee 1967) but uncommon in Kansas (Murray and Leonard 1962), Indiana (Goodrich and van der Schalie 1944), Minnesota (Dawley 1947), and Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: American eel, Anguilla rostrata; gizzard shad, Dorosoma cepedianum; rock bass, Ambloplites rupestris; white crappie, Pomoxis annularis; freshwater drum, Aplodinotus grunniens (Fuller 1978).

Commercial Value: None.

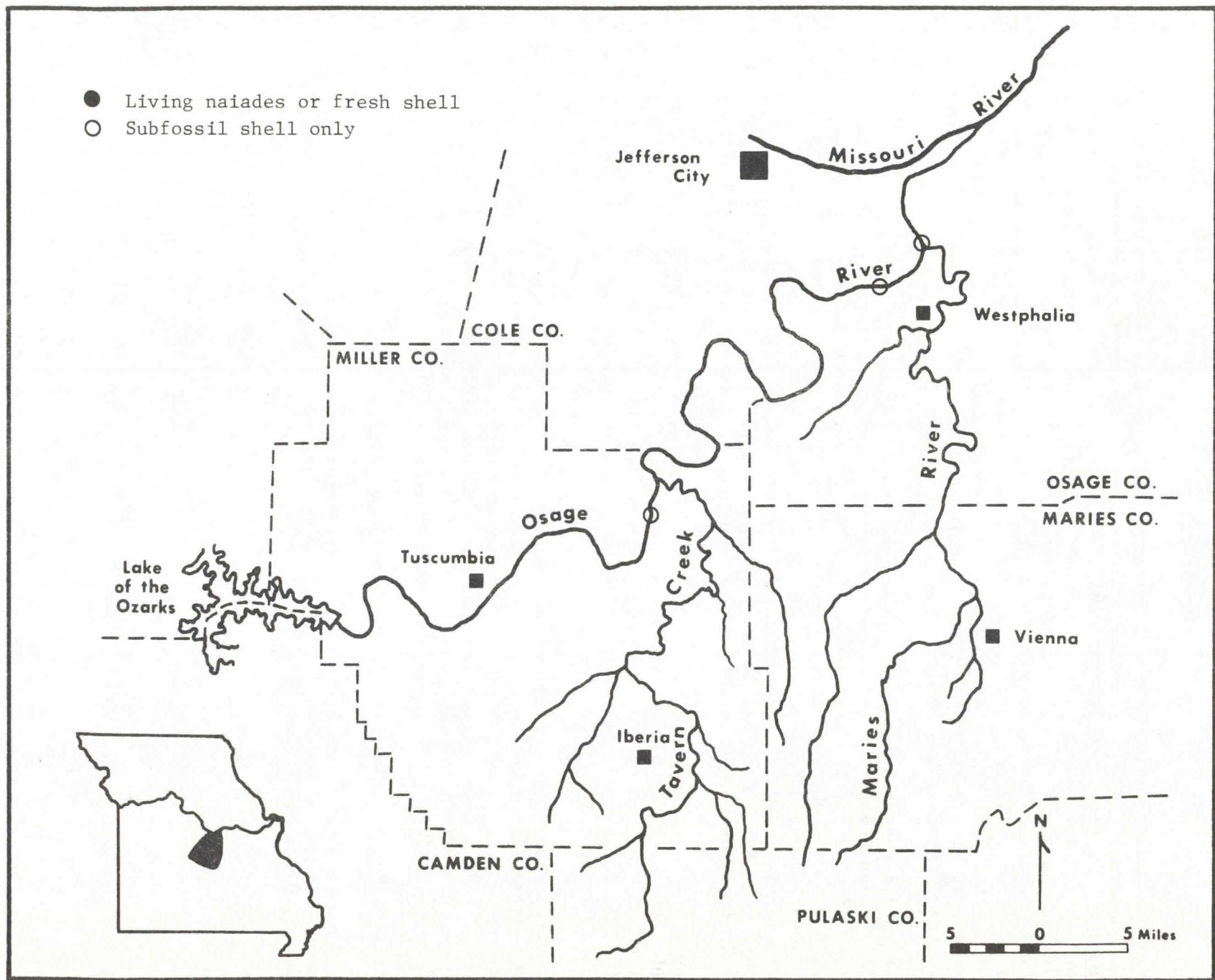


Figure 16. Distribution of *Arcidens confragous* (Say 1829) in the lower Osage River, Tavern Creek, and Maries River.

Lasmigona complanata (Barnes 1823)

White Heel-Splitter

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are generally large, subrhomboid to subelliptical, compressed and highly alate. Shells are thin when young and solid when old. Beaks are low. The beak sculpture consists of four or five heavy bars, the first two simple, the rest double-looped. Cardinal teeth are heavy; lateral teeth are represented only by slight thickenings of the hinge line. Beak cavities are shallow. The nacre is bluish to satiny white. Adults commonly 3 to 8 inches long.

Geographic Distribution: L. complanata was found in the lower Osage River from its mouth to Bagnell Dam, in the downstream 11.8 miles of the Maries River, and at one site in the downstream 5.2 miles of Tavern Creek (Fig. 17). It was common but nowhere abundant in the lower Osage River. In the past, Utterback (1915; 1917) found this species in Big Mud Lake; northwest Missouri lakes; the Platte, Mississippi and Des Moines rivers and from the Grand, Nodaway, Tarkio, Osage, Blackwater and Meramec river basins. More recently it has been reported from the Salt, North and Cuivre rivers (Duchrow 1974), the Meramec, Big and Bourbeuse rivers and Dry Fork of the Meramec (Buchanan 1980), the Little Black River (Buchanan 1979), and the Whitewater, St. Francis, Black, Spring, Wyaconda, North Fabius, Sac, Marmaton, Lamine, Loutre and Blackwater rivers, the River Aux Vases and Sandy, Grindstone, Auxvasse and Horse creeks (Oesch in press). In North America, it is found in the entire Mississippi River Basin north of the Arkansas River, the Upper St. Lawrence River Basin north to the Mackenzie River, and the Hudson Bay Basin (Parmalee 1967).

Habitat: L. complanata was found in a range of substrates from silt to boulder, in 1 inch to 15 feet of water, in standing (0.0 ft./sec. at the bottom) to moderately-flowing (1.4 ft./sec. at the bottom) water. In the Meramec and Little Black river basins this species was found in 1 inch to 5 feet of water, in a silt to gravel and cobble substrate, in standing to swiftly-flowing (1.9 ft./sec. at the bottom) water (Buchanan 1979; 1980). Other authors (Murray and Leonard 1962; Parmalee 1967; Goodrich and van der Schalie 1944) reported this species from lakes and ponds, and in a silt, gravel, or rocky substrate, in small streams to large rivers.

Relative Abundance: L. complanata comprised only 0.3% of the living naiades found in the lower Osage River Basin (Table 3). This species was also found in low numbers in the Meramec and Little Black river basins, where it comprised 0.2% or less of the living naiades found (Buchanan 1979; 1980). It is common and widespread in Missouri (Oesch in press), Illinois (Parmalee 1967), Kansas (Murray and Leonard 1962), Indiana (Goodrich and van der Schalie 1944), Minnesota (Dawley 1947), and Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Baker 1928).

Fish Host: Carp, Cyprinus carpio; green sunfish, Lepomis cyanellus; largemouth bass, Micropterus salmoides; white crappie, Poxomis annularis (Fuller 1978).

Commercial Value: None.

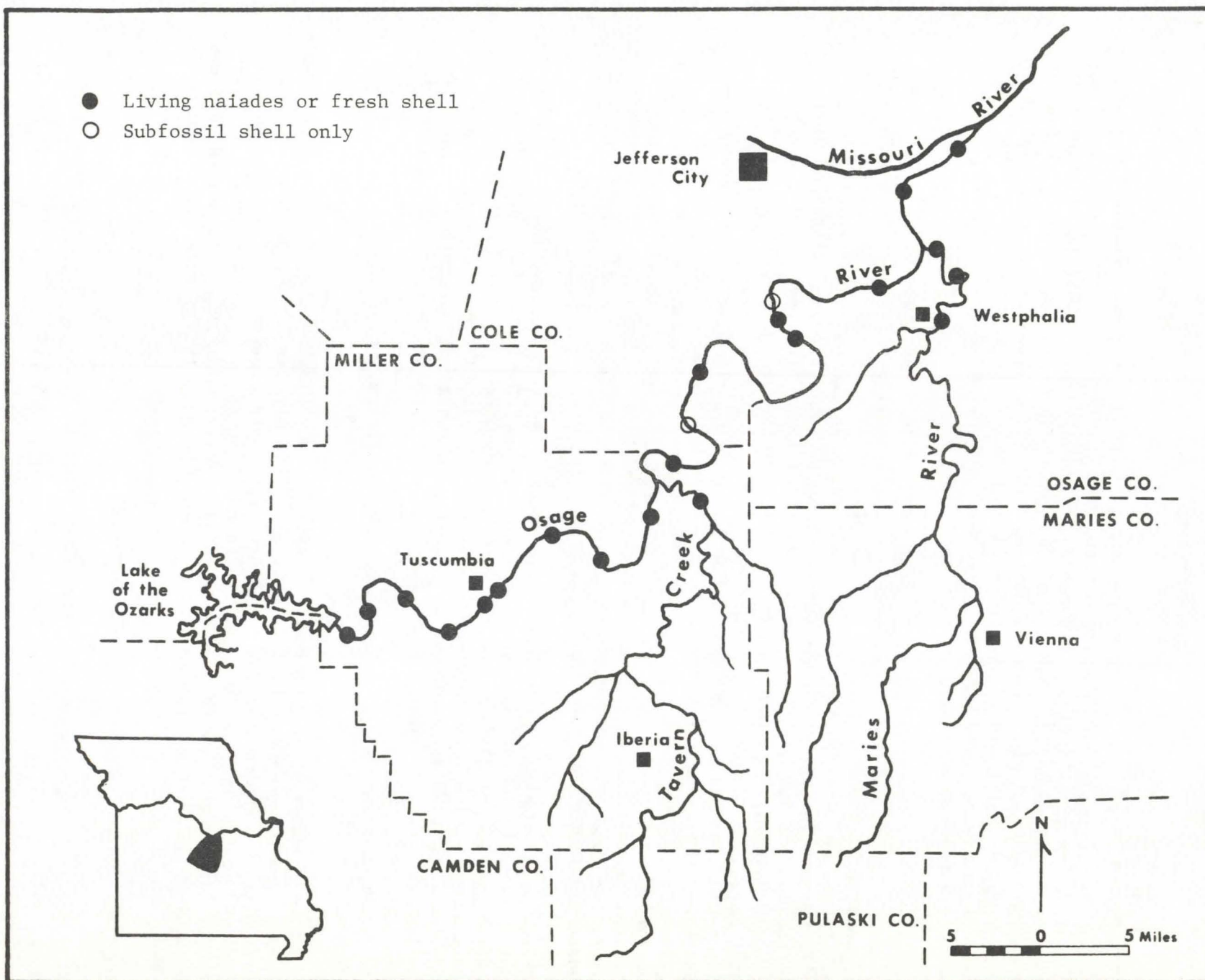


Figure 17. Distribution of Lasmigona complanata (Barnes 1823) in the lower Osage River, Tavern Creek, and Maries River.

Lasmigona costata (Rafinesque 1820)

Fluted Shell

Status: Unclassified.

Physical Description (Utterback 1915; Parmalee 1967; Baker 1928; Ortmann 1919): The shells are nearly rhomboid and elongated, solid and somewhat compressed; the anterior end is sharply rounded and the posterior end is obliquely truncated. Numerous flutings or ridges are present on the posterior ridge. Beaks are depressed and the beak sculpture consists of three to five heavy bars, the first curved, the rest somewhat double-looped. Epidermis is brown to black. Cardinal teeth are single in the right valve and tripartite in the left. Lateral teeth are nearly absent. Beak cavities are shallow. Nacre is generally white. Adults commonly 3 to 7 inches long.

Geographic Distribution: L. costata was found at only two sites in the lower Osage River, but was common in the downstream halves of the Maries River and Tavern Creek (Fig. 18). Utterback (1915; 1917) found this species in the Gasconade, Black, St. Francis, Mississippi and Des Moines rivers and in the Osage, Blackwater, Meramec and White river basins. More recently, Oesch (in press) reported that this species has a wide distribution in Missouri. L. costata is found in the entire Mississippi and Ohio river basins, the Great Lakes Basin from Lake Superior to Lake Champlain and the Ottawa River, the Hudson Bay Basin, and in the Gulf of Mexico drainage (Clarke and Berg 1959).

Habitat: L. costata occurred in a range of substrates from silt to cobble and boulder, in 1 inch to 20 feet of water, in standing (0.0 ft./sec. at the bottom) to swiftly-moving (2.6 ft./sec. at the bottom) current. Buchanan (1979; 1980) found this species in an array of substrates from silt to boulder, in 1 inch to 12 feet of water, in standing to swiftly-flowing (1.9 ft./sec. at the bottom) current in the Meramec and Little Black river basins. Other authors (Murray and Leonard 1962; Goodrich and van der Schalie 1944; Parmalee 1967) reported this species from sand or gravel substrates in slow to swift current in small streams to large rivers.

Relative Abundance: L. costata comprised only 0.4% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 1.0% and 0.6%, respectively, in the Little Black and Meramec river basins (Buchanan 1979; 1980). L. costata is common in Missouri (Oesch in press), Illinois (Parmalee 1967), Indiana (Goodrich and van der Schalie 1944), and Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Baker 1928).

Fish Host: Carp, Cyprinus carpio (Lefevre and Curtis 1910).

Commercial Value: None.

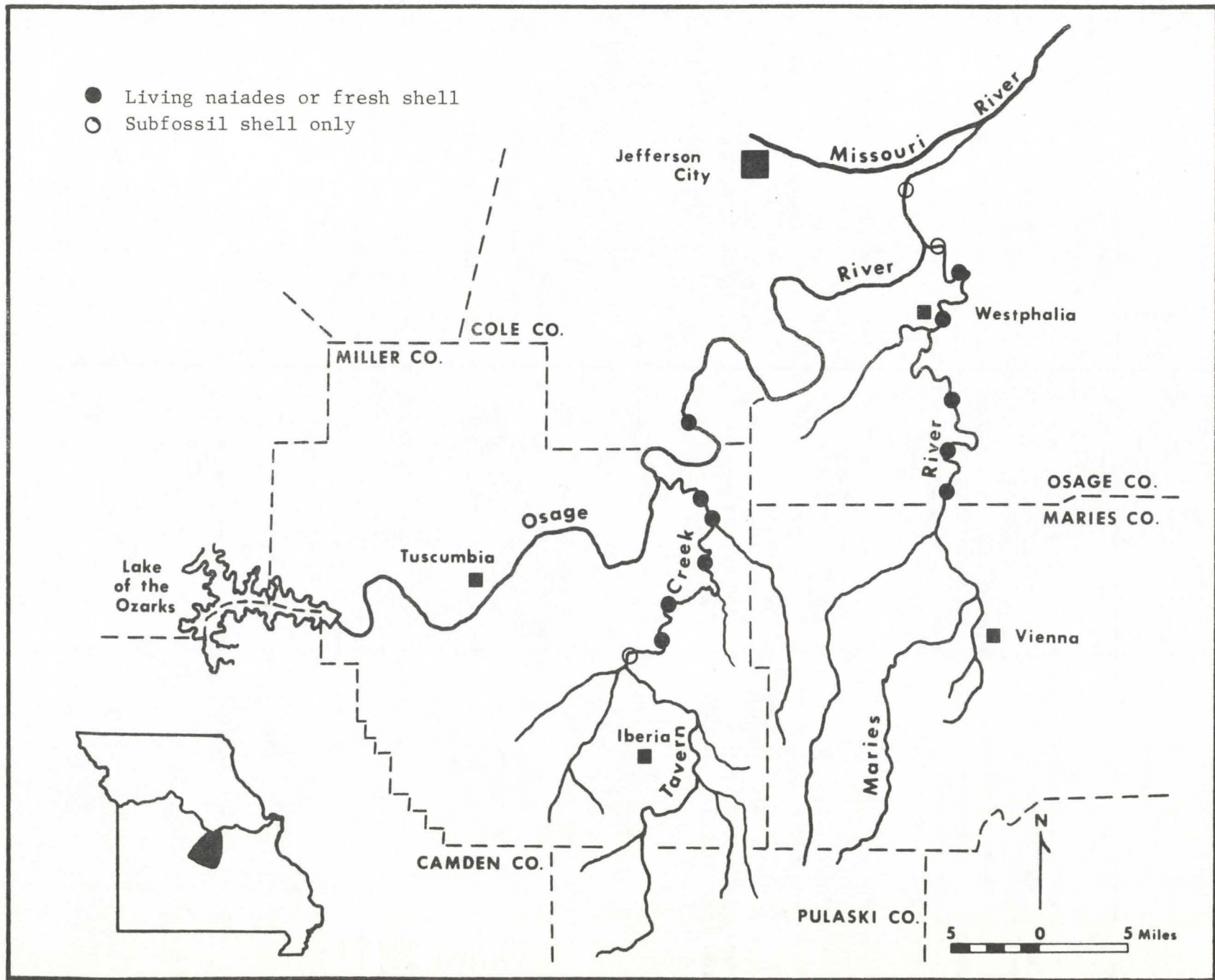


Figure 18. Distribution of Lasmigona costata (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Megaloniaias nervosa (Rafinesque 1820)

Washboard

Status: Unclassified.

Physical Description (Parmalee 1967; Baker 1928): The shells are large, thick, heavy and elongate-quadrangle in shape. Anterior end is rounded. Posterior ridge is rounded, merging in the undulations of the surface. Beaks are full but depressed; beak sculpture consists of heavy double-looped ridges, zig-zag in appearance. Shell surface has several broad, rounded oblique undulations or folds on the posterior half. Posterior margin is fluted. Cardinal teeth are massive, and triangular. Lateral teeth are long. Beak cavities are deep. Nacre is white. Adults commonly 3 to 10 inches long.

Geographic Distribution: In the lower Osage River Basin, M. nervosa was found from the mouth to Bagnell Dam in the Osage River, and in the downstream 4.9 miles of the Maries River (Fig. 19). This species was extremely abundant locally in the lower Osage River. This species was not found in Tavern Creek. Utterback (1915; 1917) reported this species from the Mississippi, Osage, Platte and Des Moines rivers and from the Chariton, Grand, Blackwater and Gasconade river basins. More recently it has been reported from the Whitewater, Salt, Gasconade, Pomme de Terre and Big Piney rivers (Oesch in press), and the Meramec, Big, and Bourbeuse rivers (Buchanan 1980). In North America M. nervosa is known from throughout the Mississippi River Basin, west to eastern Texas, Kansas, Iowa, and Wisconsin, from Red River of the North, Manitoba, Canada, the Tombigbee River, Alabama and Nuevo Leon, Northern Mexico (Murray and Leonard 1962).

Habitat: M. nervosa was found in an array of substrates from silt to boulder, in 1 inch to 20 feet of water, in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.0 ft./sec. at the bottom) water. In the Meramec River Basin (Buchanan 1980) this species was most commonly found in a silt, gravel and cobble, or cobble and boulder substrate, in 1 inch to 5 feet of water in standing to moderately-flowing (1.5 ft./sec. at the bottom) water. It typically occurs in quiet waters on a silt bottom in deep water, but may also be found on a good bottom (Murray and Leonard 1962; Parmalee 1967; Goodrich and van der Schalie 1944).

Relative Abundance: M. nervosa was the most abundant species in the lower Osage River Basin and comprised 51.5% of the living naiades found (Table 3). This species comprised 2.9% of the living naiades found in the Meramec River Basin (Buchanan 1980). M. nervosa is common in big river habitat in Missouri (Oesch in press), Illinois (Parmalee 1967), Indiana (Goodrich and van der Schalie 1944) and Minnesota (Dawley 1947).

Breeding Season: Tachytictic (Utterback 1915).

Fish Host: Gizzard shad, Dorosoma cepedianum; white crappie, Pomoxis annularis; white bass, Morone chrysops; bowfin, Amia calva; flathead catfish, Pylodictis olivaris; and 11 other fish species (Fuller 1978).

Commercial Value: Danglade (1914) reported that this species was the best button shell in the Illinois River. Starrett (1971) listed it as the second most valuable shell taken from the Illinois River for the Japanese pearl-culture industry.

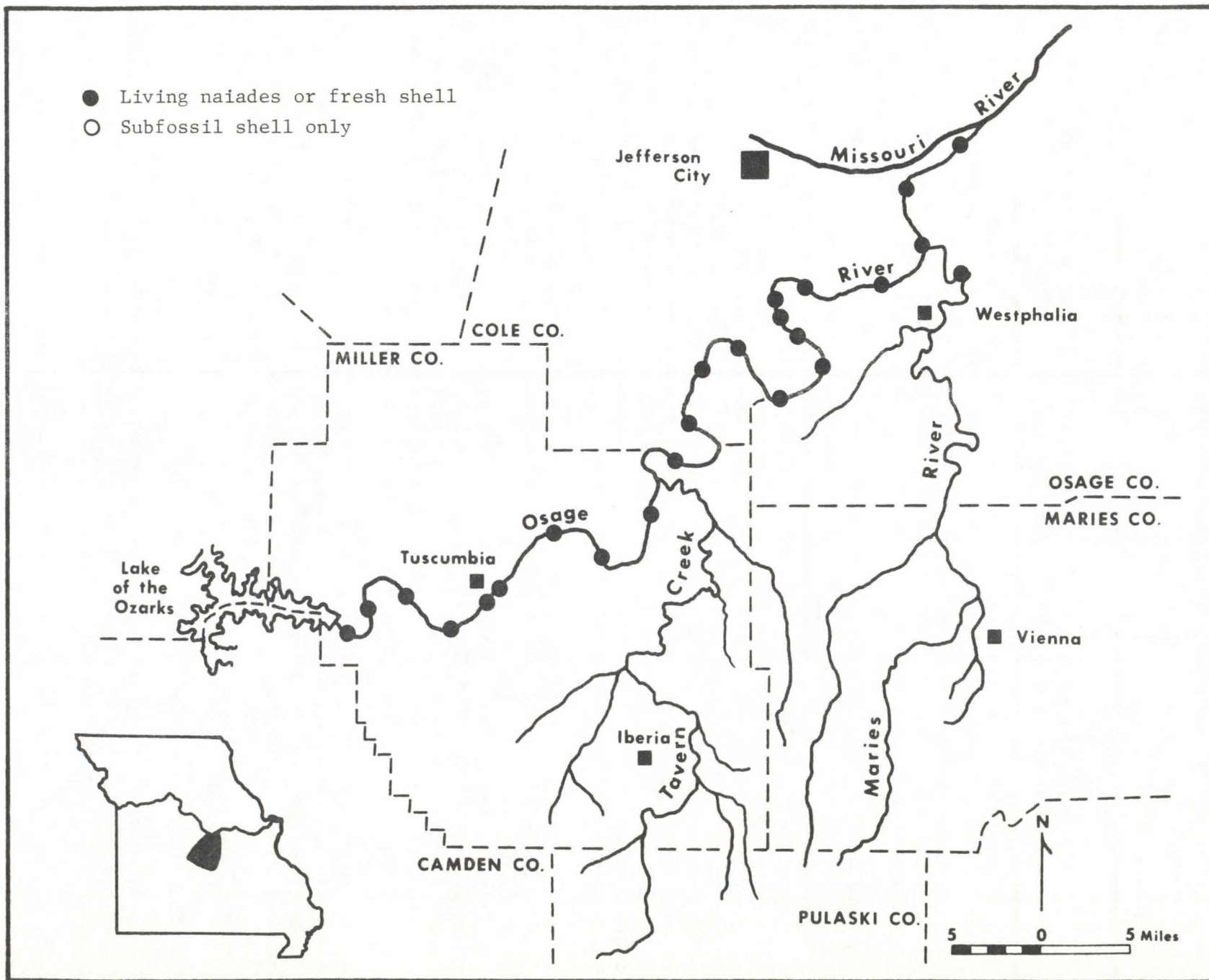


Figure 19. Distribution of Megaloniais nervosa (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Tritogonia verrucosa (Rafinesque 1820)

Buckhorn

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are solid, elongate, trapezoidal and compressed and have a pronounced, elevated, irregular posterior ridge. Anterior end is rounded; the posterior end is squared or obliquely truncated. Entire surface is covered with pustules. Beaks are low, and the beak sculpture consists of one or two subconcentric bars followed by several more or less double-looped zig-zag bars. Epidermis is yellow to black. Cardinal teeth are heavy and ragged. Lateral teeth are long and heavy. Beak cavities are deep. Nacre is white. Adults commonly 2 to 7 inches long.

Geographic Distribution: T. verrucosa was found in the downstream half of both Tavern Creek and the Maries River, and throughout the lower Osage River (Fig. 20). This species was common but nowhere abundant. Utterback (1917) reported this species from all parts of Missouri. Oesch (in press) describes a similar, present-day, distribution for this species. In North America, T. verrucosa is found generally throughout the Mississippi Basin and in Gulf-draining streams from the Alabama River system west to central Texas (Burch 1973).

Habitat: T. verrucosa was found in a range of substrates from silt to boulder, in 1 inch to 20 feet of water, in standing (0.0 ft./sec. at the bottom) to moderately-flowing (1.4 ft./sec. at the bottom) current. This species was found in an array of substrates from silt to gravel, cobble and boulder, in 2 inches to 6 feet of water in slow (less than 0.2 ft./sec. at the bottom) to moderate (1.7 ft./sec. at the bottom) current in the Meramec and Little Black river basins (Buchanan 1979; 1980). Other authors (Murray and Leonard 1962; Goodrich and van der Schalie 1944; Parmalee 1967) have found T. verrucosa on nearly all bottom types in standing to swiftly-flowing water in small streams to large rivers.

Relative Abundance: In the lower Osage River Basin T. verrucosa comprised only 0.4% of the living naiades found (Table 3). This species comprised 0.6% and 1.2%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is a common species in Missouri (Oesch in press), Illinois (Parmalee 1967) and Kansas (Murray and Leonard 1962).

Breeding Season: Tachytictic (Utterback 1917).

Fish Host: Unknown.

Commercial Value: Used in both the button and cultured pearl industries (Stansbery 1973).

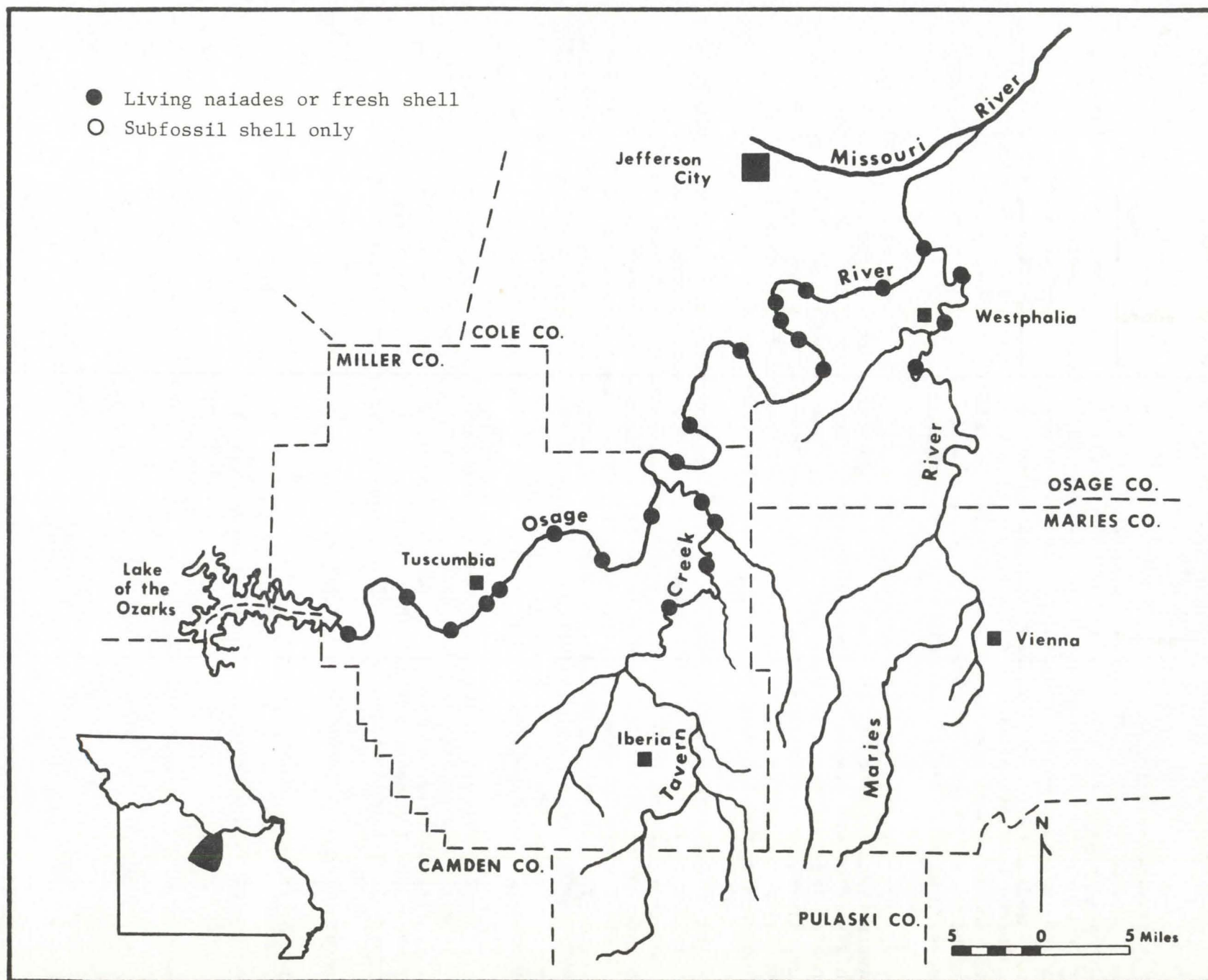


Figure 20. Distribution of Tritogonia verrucosa (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Quadrula quadrula (Rafinesque 1820)

Maple-Leaf

Status: Unclassified

Physical Description (Baker 1928; Ortmann 1919): The shells are quadrate in outline, compressed to slightly inflated and solid. Beaks are elevated above the hinge line and only slightly inflated; beak sculpture consists of double-loops or zig-zag bars. Anterior end is rounded; the posterior end is truncated. A sulcus is present anterior to the posterior ridge. One row of tubercles is found on the posterior ridge and another row is present anterior to the sulcus. Epidermis is yellow to black; rays are indistinct in young specimens. Cardinal teeth are ragged, divergent and triangular. Lateral teeth are wide and long. Beak cavities are deep. Nacre is white. Adults commonly 1 to 5 inches long.

Geographic Distribution: Q. quadrula was found in the lower Osage River from its mouth to Bagnell Dam and in the downstream 11.8 miles of the Maries River (Fig. 21). None were found in Tavern Creek. Utterback (1915; 1917) found this species in the Mississippi, Des Moines, Platte, Osage, Aux Vases and Grand rivers; the Nodaway, Chariton, Blackwater and Tarkio river basins; Lake Contrary and northwest Missouri lakes. Oesch (in press) reported this species from all regions of Missouri. In North America, Q. quadrula occurs in most of the tributaries of the Mississippi River, the Great Lakes drainage, the St. Lawrence River Basin, Red River of the North, the Alabama River system and in some streams of eastern and central Texas (Burch 1973).

Habitat: Q. quadrula occurred in an array of substrates from silt to boulder, in 1 inch to 20 feet of water in standing (0.0 ft./sec. at the bottom) to moderately-flowing (1.4 ft./sec. at the bottom) current. In the Meramec River Basin, Q. quadrula was found in a silt, gravel, gravel and cobble, or cobble and boulder substrate in 1 inch to 3 feet of water in slow (less than 0.2 ft./sec. at the bottom) to moderate (1.5 ft./sec. at the bottom) current (Buchanan 1980).

Relative Abundance: Q. quadrula comprised only 0.2% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 0.4% of the living naiades found in the Meramec River Basin (Buchanan 1980). It is a common species in Missouri (Oesch in press), Illinois (Parmalee 1967), Kansas (Murray and Leonard (1962), and Indiana (Goodrich and van der Schalie 1944) and uncommon in Wisconsin (Mathiak 1979).

Breeding Season: Tachytictic (Utterback 1915).

Fish Host: Flathead catfish, Pylodictis olivaris (Coker et al. 1921).

Commercial Value: At one time commercially valuable for the pearl button and/or pearl culture industries (Stansbery 1973).

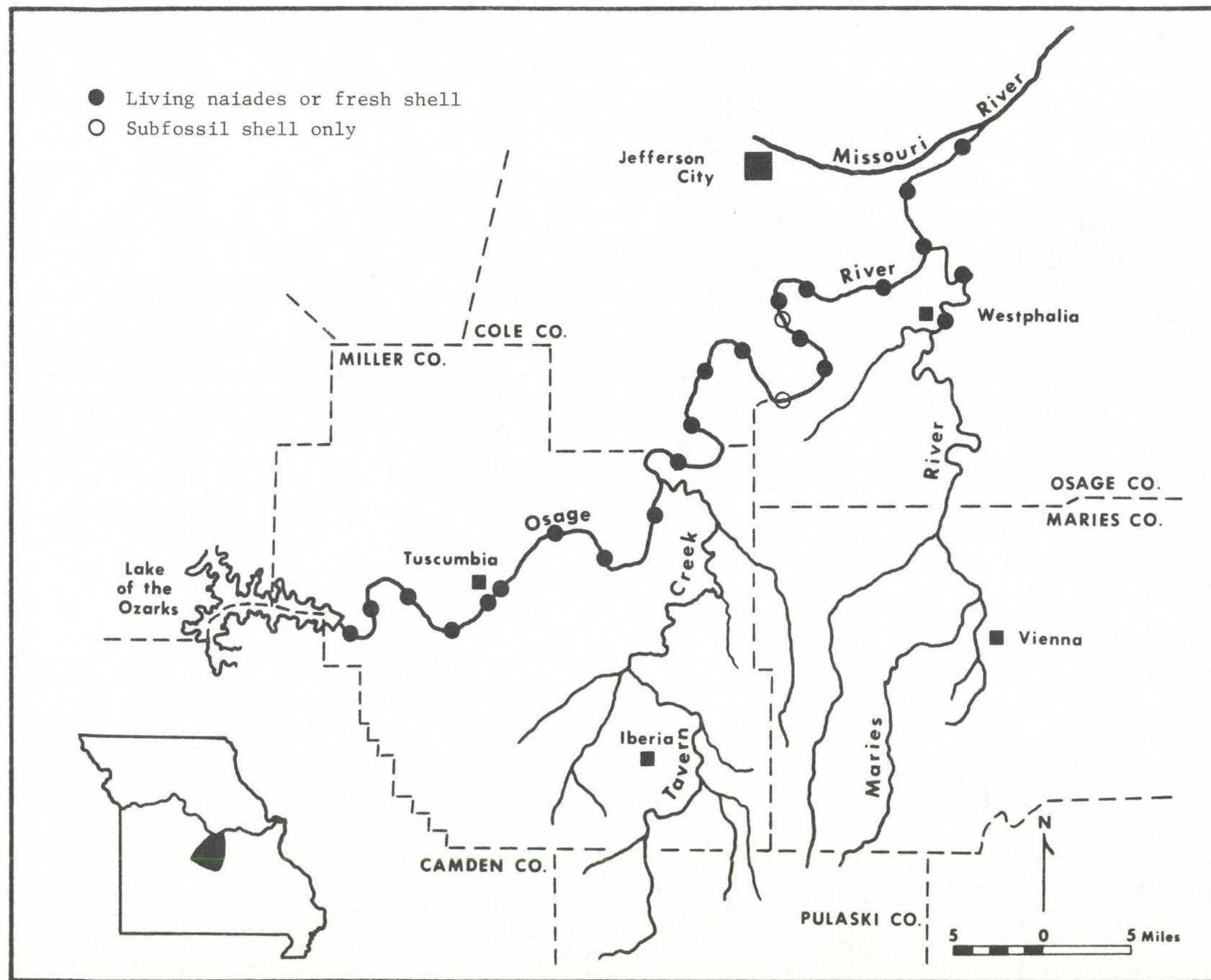


Figure 21. Distribution of Quadrula quadrula (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Quadrula metanevra (Rafinesque 1820)

Monkey-Face

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are solid, inflated and squared or rhomboid. Anterior end is rounded and the posterior end is squared or truncated. Posterior ridge is prominent and raised. Beaks are slightly to moderately elevated; beak sculpture consists of two or three sub-concentric ridges with nodules on the posterior ridge. Posterior two-thirds of shell is covered with rounded tubercles, which become much larger on the posterior ridge. Epidermis is yellowish-green or brown, with chevron-shaped dark green markings. Cardinal teeth are heavy, triangular, divergent and ragged. Lateral teeth are short, wide, and heavy. Beak cavities are moderately deep to deep. Nacre is white. Adults commonly 1 to 4 inches long.

Geographic Distribution: In the lower Osage River Basin, Q. metanevra was found only in the Osage River, where it was common but never abundant, from Bagnell Dam to the mouth (Fig. 22). Utterback (1917) found this species in the Mississippi and Des Moines rivers and in the Grand, Osage, Meramec, Gasconade, Neosho, White and Black river basins. More recently, Oesch (in press) reported this species from the Whitewater, St. Francis, Black, Salt, Gasconade, Sac, Pomme de Terre, Big Piney and Spring rivers and from the River Aux Vases, and Buchanan (1980) reported it from the Meramec, Big, and Bourbeuse rivers. In North America, Q. metanevra has been reported from the Mississippi River Basin, Ohio River Basin, Black River system, and the White and St. Francis rivers (Johnson 1980).

Habitat: Q. metanevra occurred in a range of substrates from silt to boulder, in 3 inches to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.0 ft./sec. at the bottom) current. In the Meramec River Basin, Q. metanevra was usually collected in a gravel and cobble substrate, in 1 inch to 5 feet of water, in standing to moderately-flowing (1.5 ft./sec. at the bottom) water (Buchanan 1980). Parmalee (1967), Goodrich and van der Schalie (1944) and Stansbery (1973) found it on bottoms free of mud in swift current in medium-sized and large rivers.

Relative Abundance: Q. metanevra comprised 1.6% of the living naiades found in the lower Osage River Basin (Table 3). In the Meramec River Basin this species comprised only 0.2% of the living naiades found (Buchanan 1980). This species is common in central Missouri (Oesch in press), Illinois (Parmalee 1967) and Indiana (Goodrich and van der Schalie 1944) and uncommon in Wisconsin (Mathiak 1979).

Breeding Season: Tachytictic (Utterback 1915).

Fish Host: Bluegill, Lepomis macrochirus; sauger, Stizostedion canadense; green sunfish, Lepomis cyanellus (Fuller 1978).

Commercial Value: Valuable at one time for the pearl button industry (Stansbery 1973).

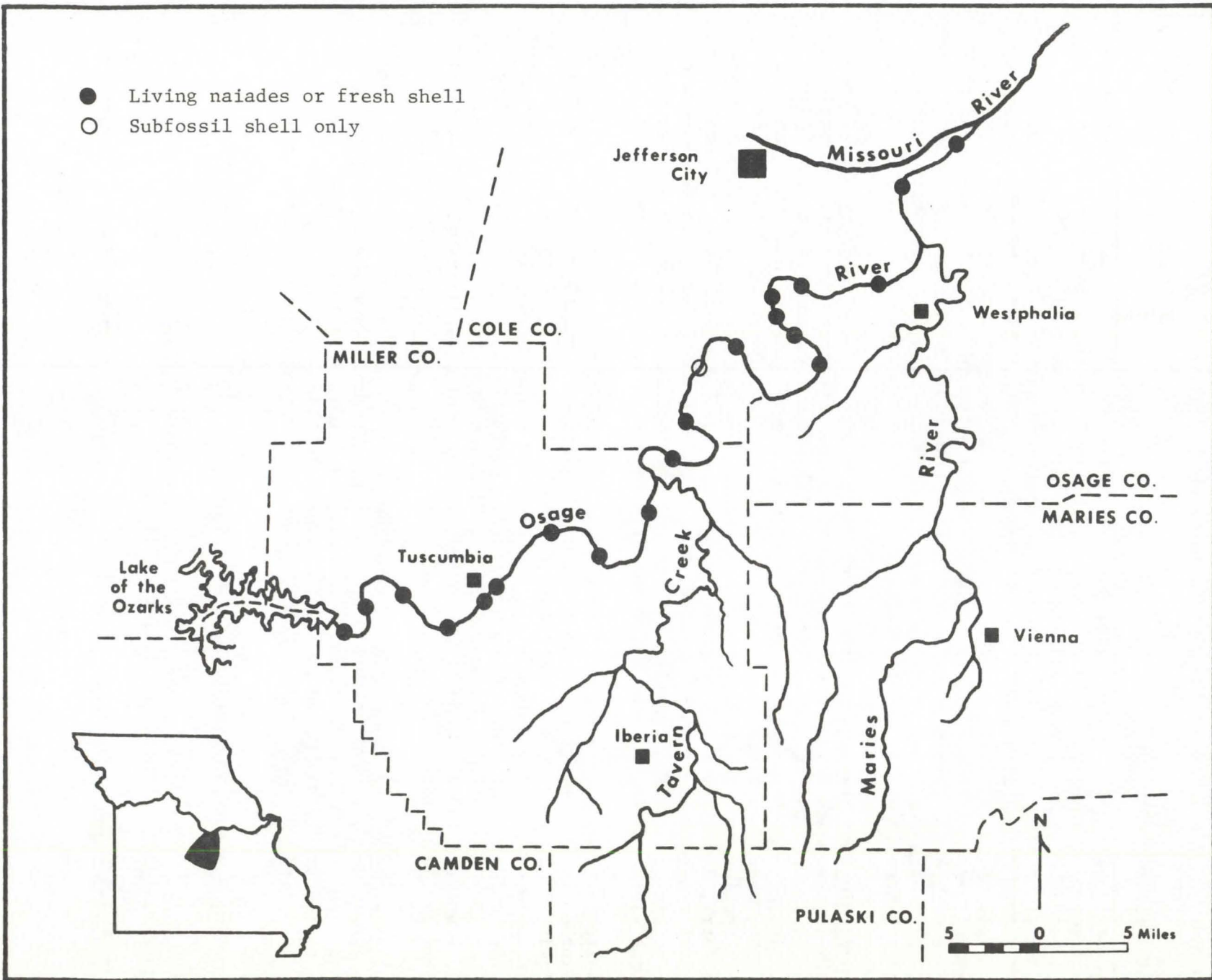


Figure 22. Distribution of Quadrula metanevra (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Quadrula pustulosa (Lea 1831)

Pimple-Back

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are rounded to quadrate, solid and moderately inflated. Anterior end is rounded and the posterior end is rounded to squarish or truncated. Beaks are high, swollen and turned forward; beak sculpture consists of two to three indistinct concentric ridges. Posterior two-thirds of shell is usually covered with rounded tubercles or pustules. Shell is sometimes smooth in young specimens. Posterior ridge is rounded. The epidermis is yellowish-green to black. Cardinal teeth are triangular, elevated and ragged. Lateral teeth are short, straight and heavy. Beak cavities are deep. The nacre is white. Adults commonly 1 to 3 inches long.

Geographic Distribution: Q. pustulosa was found in the lower Osage River from its mouth to Bagnell Dam, in the downstream 11.8 miles of Maries River, and the downstream 17.0 miles of Tavern Creek (Fig. 23). This species was extremely abundant locally in the lower Osage River. Utterback (1915; 1917) reported this species from the Mississippi, Grand, Platte, Des Moines, and Osage rivers and the Chariton, Nodaway, Tarkio, Meramec and Gasconade river basins. More recently, Oesch (in press) reported this species from all parts of Missouri. In North America, Q. pustulosa is known from the Ohio-Mississippi River system from Lake Erie to Alabama and from Kansas to West Virginia (Johnson 1980).

Habitat: Q. pustulosa occurred in all bottom types from silt to boulder, in 1 inch to 20 feet of water, in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.6 ft./sec. at the bottom) water. This species was found in similar habitats in the Meramec and Little Black river basins (Buchanan 1979; 1980). Other authors (Parmalee 1967; Murray and Leonard 1962; Goodrich and van der Schalie 1944) reported this species from all habitats except shifting sand in small streams to large rivers.

Relative Abundance: In the lower Osage River Basin Q. pustulosa comprised 8.1% of the living naiades found (Table 3). This species comprised approximately 4% of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). Q. pustulosa is common in Missouri (Oesch in press), Illinois (Parmalee 1967), southeastern Kansas (Murray and Leonard 1962), Indiana (Goodrich and van der Schalie 1944) and southern Wisconsin (Mathiak 1979).

Breeding Season: Tachytictic (Utterback 1915).

Fish Host: Channel catfish, Ictalurus punctatus; flathead catfish, Pylodictis olivaris; white crappie, Poxomis annularis; black bullhead, Ictalurus melas; brown bullhead, Ictalurus nebulosus; shovelnose sturgeon, Scaphirhynchus platyrhynchus (Fuller 1978).

Commercial Value: Valuable at one time for the pearl button industry (Stansbery 1973).

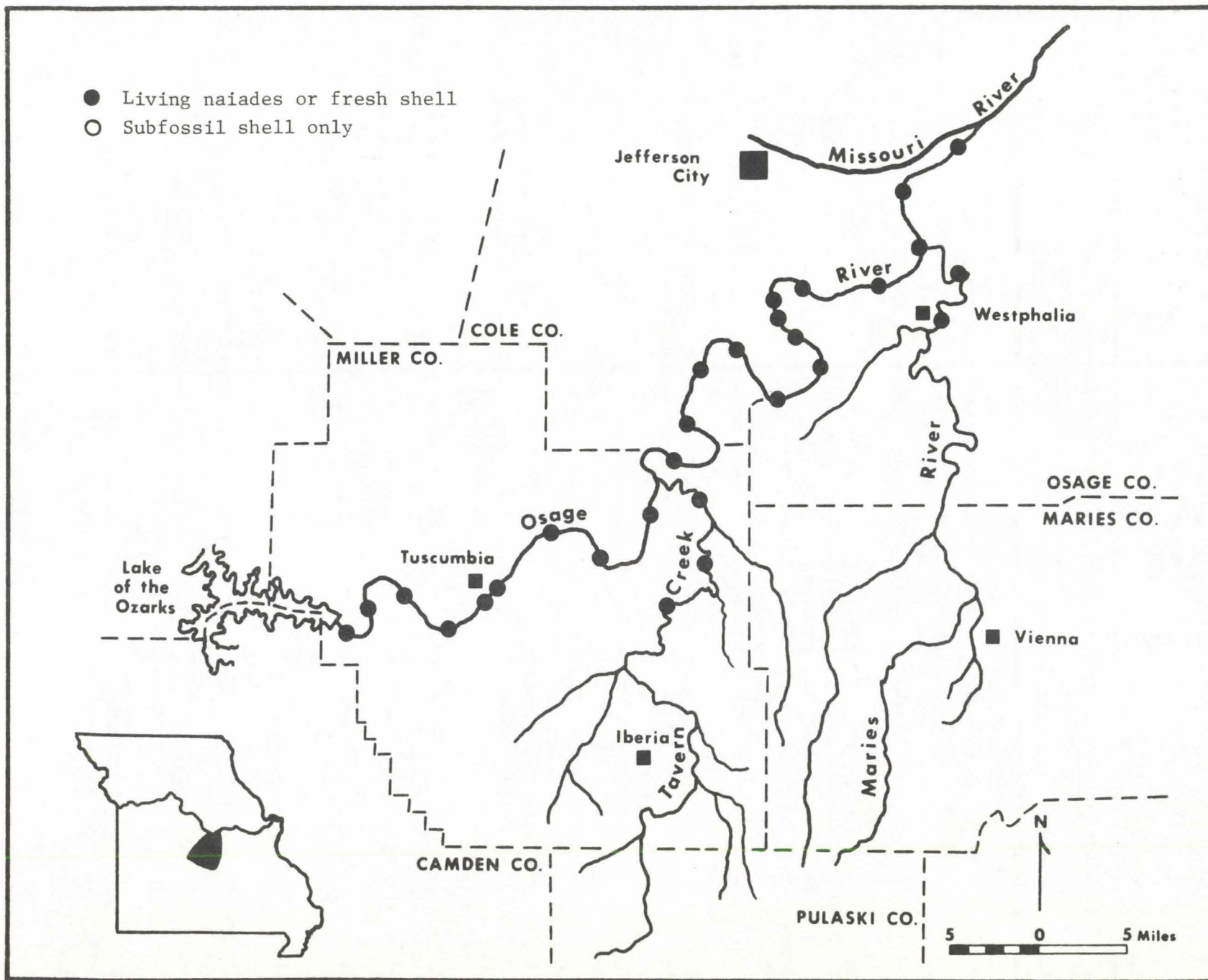


Figure 23. Distribution of Quadrula pustulosa (Lea 1831) in the lower Osage River, Tavern Creek, and Maries River.

Amblema plicata plicata (Say 1817)

Three-Ridge

Status: Unclassified.

Physical Description (Baker 1928; Parmalee 1967): The shells are suboval to subquadrate, thick and heavy. Beaks are unelevated to elevated; beak sculpture consists of three to five concentric ridges. The posterior half of the shell has none to several folds or ridges parallel to the posterior ridge. Epidermis is yellowish-brown to black. Cardinal teeth are double, heavy, divergent and triangular. Lateral teeth are heavy, long and nearly straight. Beak cavities are deep and narrow. Nacre is white. Adults commonly 1 to 7 inches long.

Geographic Distribution: A. p. plicata was found in the Osage and Maries rivers and Tavern Creek (Fig. 24). It occurred in all areas of these streams except headwater areas. This species was extremely abundant locally. Utterback (1917) found this species throughout Missouri as did Oesch (in press) during a more recent survey. In North America, A. p. plicata is reported from western New York to Minnesota, in eastern Kansas and Texas, in the Alabama River Basin, the St. Lawrence River Basin, Red River of the North, the Saskatchewan River and Lake Winnipeg (Burch 1973).

Habitat: A. p. plicata occurred in all substrates except shifting sand, in 1 inch to 20 feet of water, in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.6 ft./sec. at the bottom) water. Buchanan (1979; 1980) found it in similar habitats in the Meramec and Little Black river basins. Murray and Leonard (1962) and Parmalee (1967) reported it from small streams, large rivers, lakes, and all substrate types except shifting sand.

Relative Abundance: A. p. plicata comprised 9.1% of the living naiades found in the lower Osage River Basin, it was the second most abundant species found (Table 3). This species was the most abundant species in the Meramec River Basin where it comprised 18.1% of the living naiades found (Buchanan 1980). A. p. plicata comprised 3.7% of the living naiades found in the Little Black River Basin (Buchanan 1979). This species is common throughout most of its range.

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: White crappie, Pomoxis annularis; black crappie, Pomoxis nigromaculatus; yellow perch, Perca flavescens; rock bass, Ambloplites rupestris; green sunfish, Lepomis cyanellus; bluegill, Lepomis macrochirus; sauger, Stizostedion canadense; and 10 other species (Fuller 1978).

Commercial Value: It was the most valuable shell taken in the Illinois River for use in Japanese pearl-culture during the 1960's (Starrett 1971).

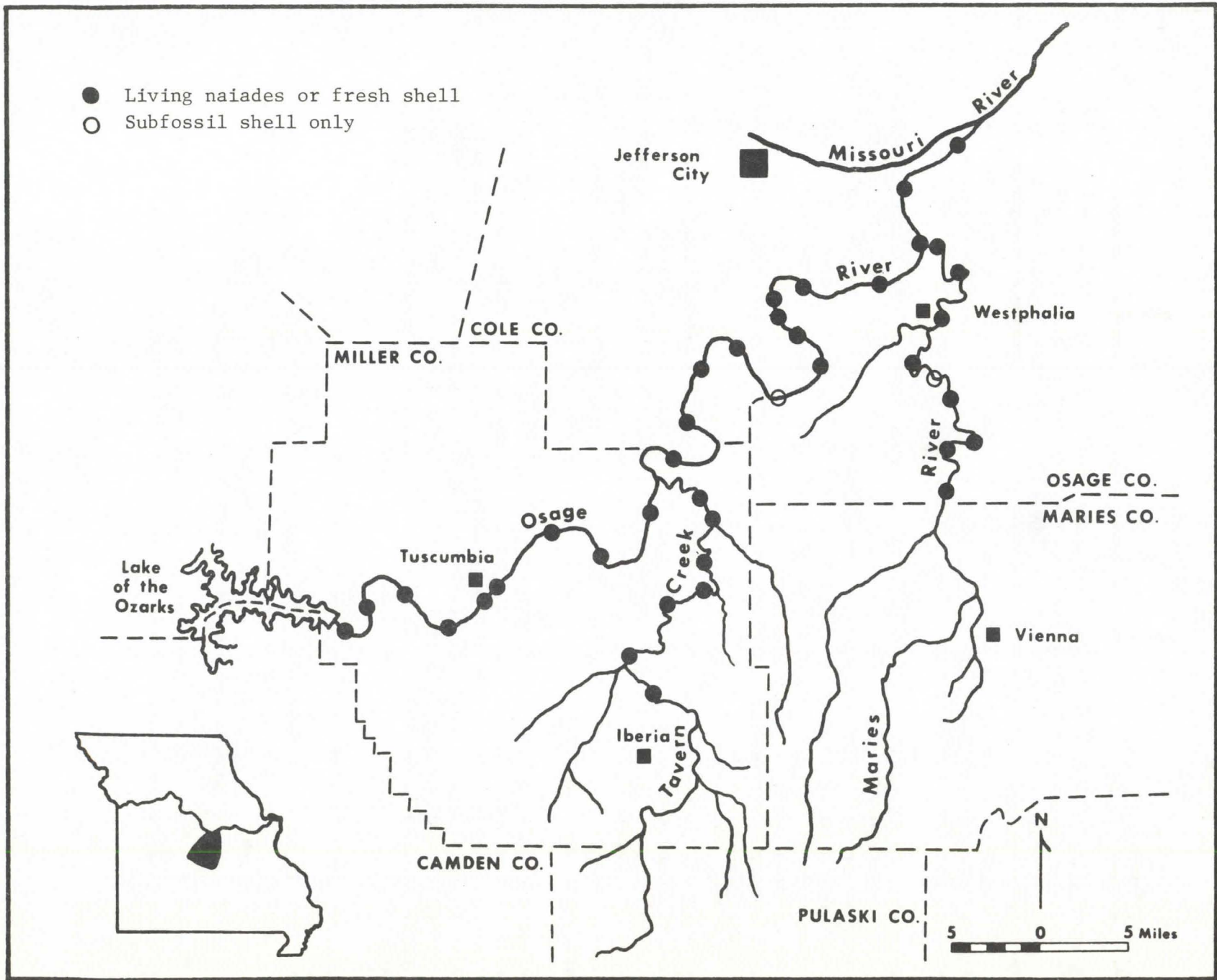


Figure 24. Distribution of Amblema plicata plicata (Say 1817) in the lower Osage River, Tavern Creek, and Maries River.

Fusconaia ebena (Lea 1831)

Ebony Shell

Status: Rare in Missouri (Missouri Department of Conservation 1977).

Physical Description (Utterback 1915; Baker 1928; Parmalee 1967): The shells are thick, solid and subrotund. Beaks are inflated, incurved and project forward; beak sculpture is faint and consists of several corrugations. Epidermis is reddish-brown to black. Cardinal teeth are large and massive. Lateral teeth are long and heavy. Cardinal teeth are parallel to the lateral teeth. Beak cavities are very deep. The nacre is white. Adults commonly 1 to 4 inches long.

Geographic Distribution: No F. ebena were found in the lower Osage River Basin during this study. Oesch (in press) found subfossil shells of this species in the Osage River between Bagnell Dam and the Miller/Cole county line but found no living specimens (Fig. 25). F. ebena may no longer occur in the lower Osage River. Early in this century, Utterback (1915) reported F. ebena from the Mississippi, Osage, Platte, St. Francis, and White rivers. More recently it has been found in the Osage, Gasconade, White, and Black river basins (Oesch in press), in the lower Meramec River (Buchanan 1980), and in the lower Little Black River (Buchanan 1979). F. ebena is also known from the Mississippi River system, Ohio River system, and the Neosho River (Johnson 1980) and the Alabama and Tombigbee rivers (Burch 1973).

Habitat: F. ebena was found in a hard mud to a gravel and cobble substrate in 1 inch to 5 feet of water in slowly-moving (less than 0.2 ft./sec. at the bottom) water in the Meramec and Little Black river basins (Buchanan 1979; 1980). This species has been found in a sand and gravel substrate in swift current in large rivers by other researchers (Parmalee 1967; Baker 1928; Goodrich and van der Schalie 1944).

Relative Abundance: F. ebena was not found in the lower Osage River Basin during this study (Table 3). This species comprised less than 0.1% of the living naiades found in both the Meramec and Little Black river basins (Buchanan 1979; 1980). F. ebena is very uncommon in Missouri (Oesch in press) and Wisconsin (Mathiak 1979), unknown in Minnesota (Dawley 1947) and Kansas (Murray and Leonard 1962), but locally abundant in large rivers in Illinois (Parmalee 1967).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Skipjack herring, Alosa chrysochloris; green sunfish, Lepomis cyanellus; largemouth bass, Micropterus salmoides; white crappie, Pomoxis annularis; black crappie, Pomoxis nigromaculatus (Fuller 1978).

Commercial Value: The most valuable button shell in the United States (Danglade 1914).

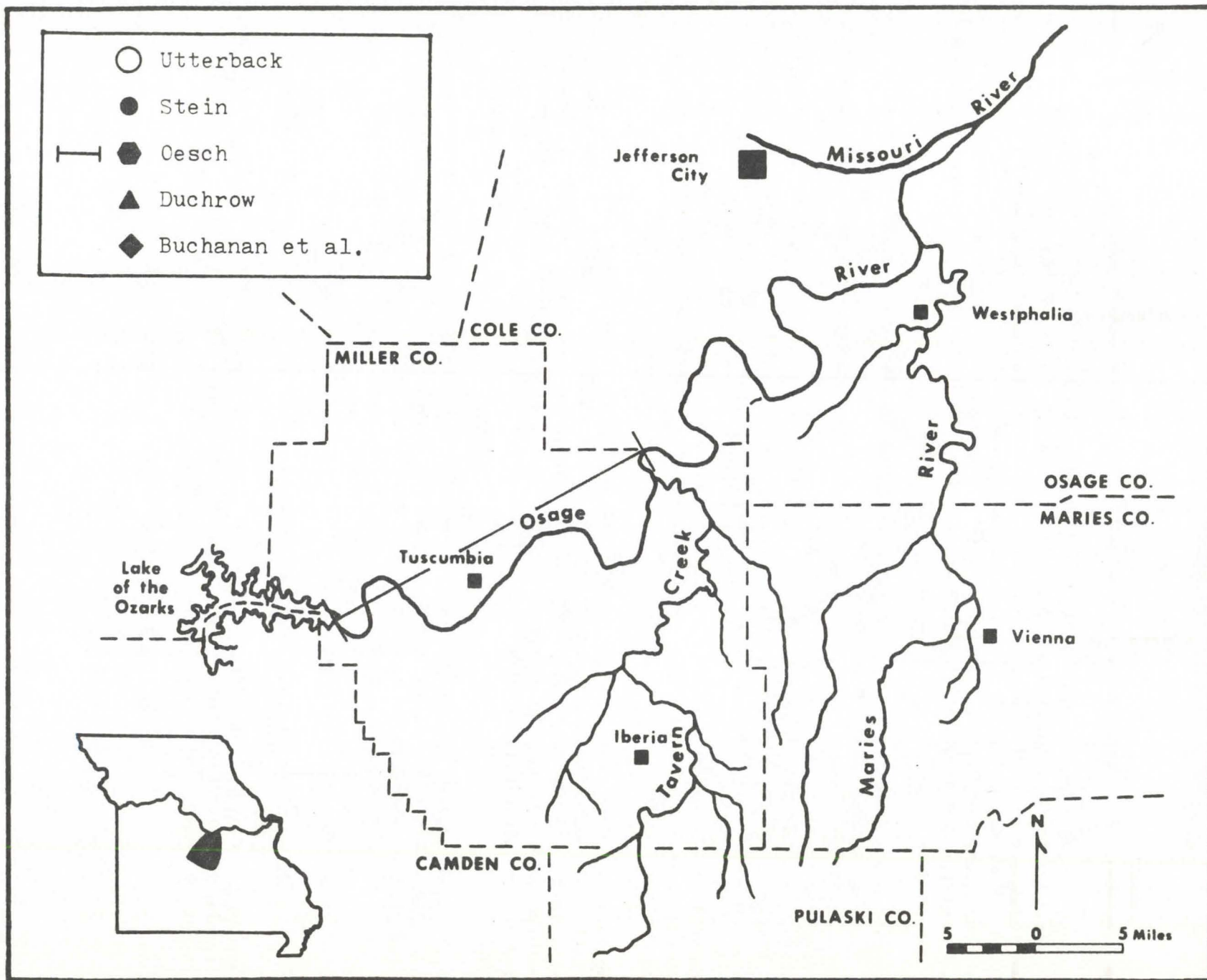


Figure 25. Distribution of Fusconaia ebena (Lea 1831) in the lower Osage River, Tavern Creek, and Maries River.

Fusconaia flava (Rafinesque 1820)

Pig-Toe

Status: Unclassified.

Physical Description (Baker 1928; Parmalee 1967; Ortmann 1919): The shells are elongate-quadrate, thin to moderately solid and compressed to slightly inflated. The anterior end is rounded and the posterior end is obliquely truncated. Beaks are depressed and turned forward; beak sculpture consists of three to five sub-concentric bars which form an angle on the posterior ridge. There is usually a wide, shallow depression anterior to the posterior ridge. Epidermis is yellowish-brown to brown, and satiny. Cardinal teeth are elevated, triangular, and divergent. Lateral teeth are thin, high, and nearly straight. Beak cavities are deep. Nacre is white. Adults commonly 1 to 3 inches long.

Geographic Distribution: F. flava was found in the Osage River from its mouth to Bagnell Dam, in the downstream 29.0 miles of Maries River, and in the downstream 23.7 miles of Tavern Creek (Fig. 26). It was common and locally abundant in the lower Osage River. Utterback (1917) reported this species from the Des Moines River and the Platte, Osage, Meramec, Gasconade, White, and Black river basins. More recently, it has been found throughout Missouri (Oesch in press). In North America, F. flava is reported from the entire Mississippi River Basin; from western New York to eastern Kansas, Nebraska, and South Dakota, south to Texas, from the St. Lawrence River, Red River of the North, and from southern Ontario (Parmalee 1967; Murray and Leonard 1962).

Habitat: F. flava was found in an array of substrates from silt to cobble and boulder, in 1 inch to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.6 ft./sec. at the bottom) water. In the Meramec and Little Black river basins F. flava occurred in a range of substrates from silt to gravel, cobble and boulder, in 1 inch to 12 feet of water in standing to swiftly-moving (2.0 ft./sec. at the bottom) water, and appeared to have no substrate preference (Buchanan 1979; 1980). F. flava was found on all bottom types except shifting sand in slow current or standing water in small streams, medium-sized and large rivers and river-lakes in other studies (Parmalee 1967; Murray and Leonard 1962; Goodrich and van der Schalie 1944).

Relative Abundance: F. flava comprised 2.7% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 3.7% and 16.4%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). F. flava is common in Missouri (Oesch in press), Illinois (Parmalee 1967), southeastern Kansas (Murray and Leonard 1962), Indiana (Goodrich and van der Schalie 1944) and Wisconsin (Mathiak 1979).

Breeding Season: Tachytictic (Baker 1928).

Fish Host: Bluegill, Lepomis macrochirus; white crappie, Pomoxis annularis; black crappie, Pomoxis nigromaculatus (Fuller 1978).

Commercial Value: This shell was used in the shell button industry where it was abundant and the shell was thick enough (Stansbery 1973; Danglade 1914).

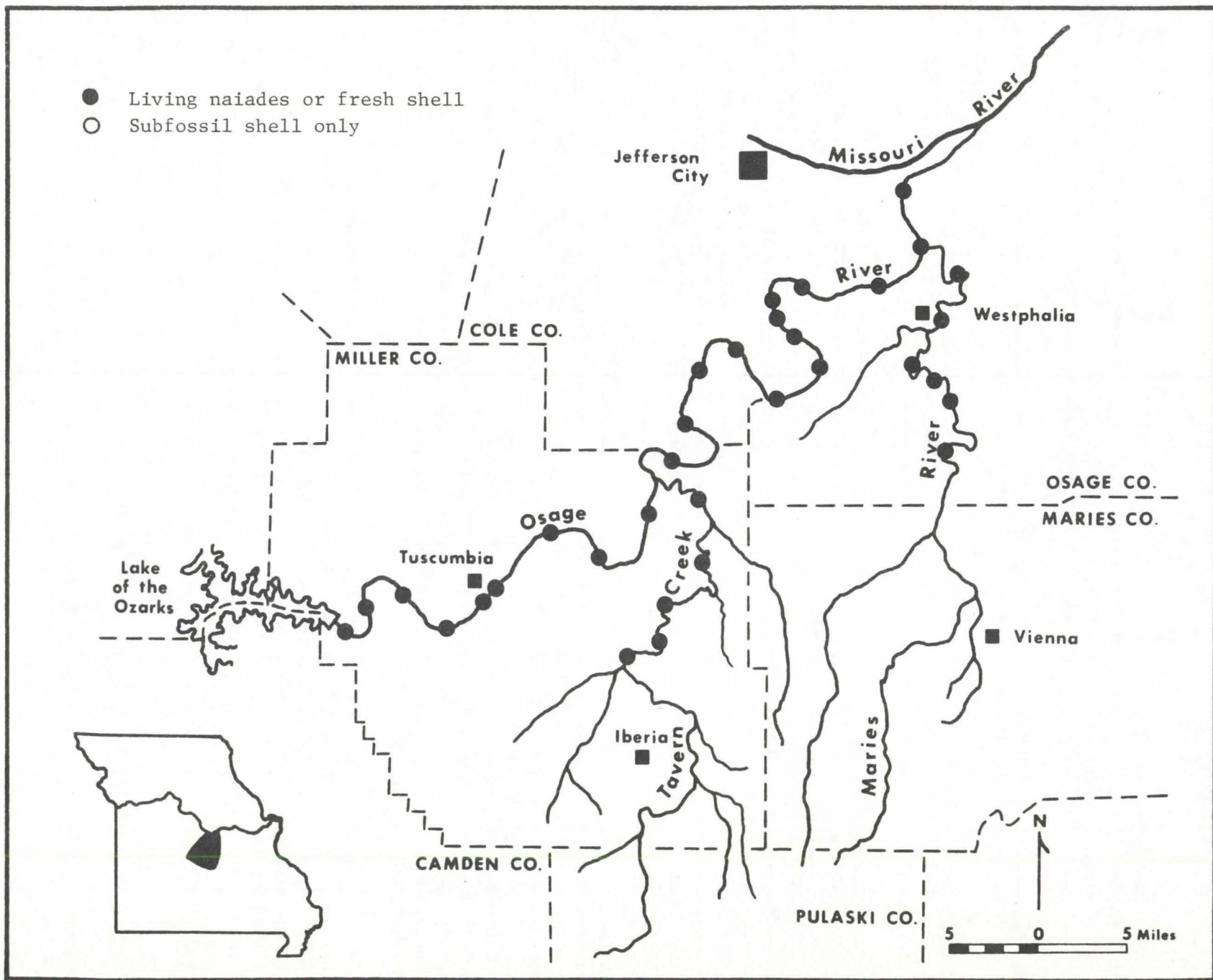


Figure 26. Distribution of *Fusconaia flava* (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Cyclonaias tuberculata (Rafinesque 1820)

Purple Warty-Back

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are compressed to inflated, subrotund, ovate or subquadrate, thick and heavy and rounded anteriorly. Beaks are depressed to moderately swollen and turned forward; beak sculpture consists of many fine, irregular, broken ridges made up of zig-zag bars with posterior loops. The center and posterior surface of the shell is covered with rounded or elongated tubercles. Parallel ridges are present on the dorso-posterior slope. Epidermis is light to dark brown, or green. Cardinal teeth are heavy, divergent and ragged. Lateral teeth are short and heavy. Beak cavities are deep and compressed. Nacre is purple to brownish-purple. Adults commonly 1 to 4 inches long.

Geographic Distribution: In the lower Osage River Basin, C. tuberculata was found in the Osage River and the downstream 5.2 miles of Tavern Creek; none were found in Maries River (Fig. 27). This species was common and extremely abundant locally between river miles 13.6 and 80.8 in the Osage River. No living specimens were found in Tavern Creek. Early in this century, Utterback (1915; 1917) reported C. tuberculata from the Mississippi, Des Moines, Osage, Meramec, Gasconade, and White rivers and from the Neosho, Black, and St. Francis river basins. More recently it has been reported from the St. Francis, Black, Salt, Gasconade, Sac, Pomme de Terre, Niangua, Current, Eleven Point, James, Elk, and North Fork of the White rivers (Oesch in press), the Little Black River (Buchanan 1979), and the Meramec and Bourbeuse rivers (Buchanan 1980). In North America, C. tuberculata has been reported from the Mississippi River Basin, the Lake St. Clair drainage, Lake Erie, the Ohio River Basin, and the Cumberland and Tennessee river systems (Burch 1973; Parmalee 1967).

Habitat: C. tuberculata occurred in a range of substrates from silt and sand to coarse gravel, cobble and boulder, in 3 inches to 20 feet of water in standing (0.0 ft./sec. at the bottom) to moderately-flowing (1.4 ft./sec. at the bottom) water. It was found in similar substrate and current in the Meramec and Little Black river basins (Buchanan 1979; 1980). Other authors (Parmalee 1967; Goodrich and van der Schalie 1944) found it in gravel/silt bottoms in a moderate or swift current in medium and large-sized rivers. This species does not occur in headwater areas.

Relative Abundance: C. tuberculata comprised 4.9% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 0.4% and 3.1%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is common in Missouri (Oesch in press) and Indiana (Goodrich and van der Schalie 1944), uncommon in Minnesota (Dawley 1947) and Wisconsin (Mathiak 1979) and not listed for Kansas (Murray and Leonard 1962).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Unknown.

Commercial Value: None.

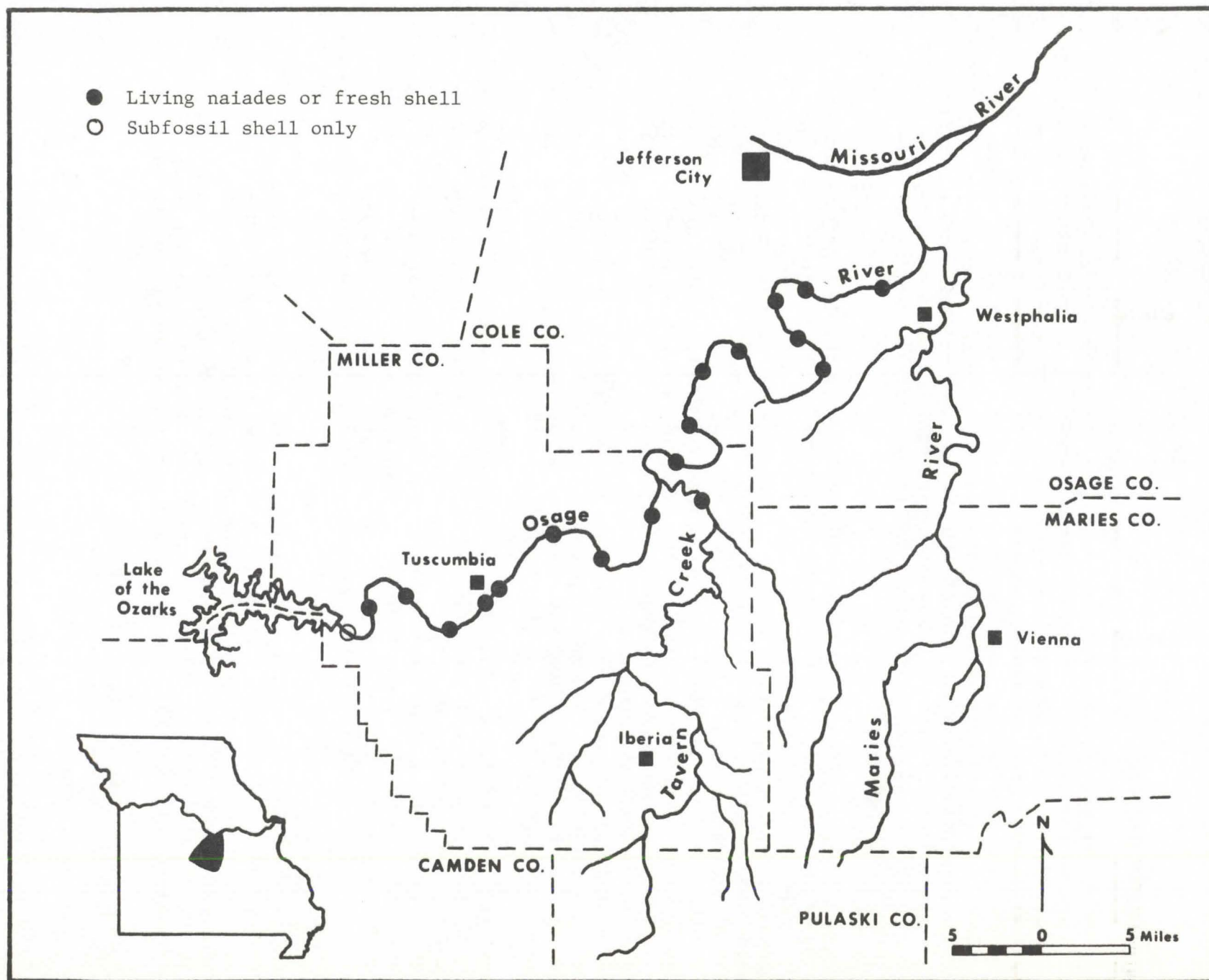


Figure 27. Distribution of Cyclonaias tuberculata (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Pleurobema coccineum (Conrad 1836)

Round Pig-Toe

Status: Unclassified.

Physical Description (Baker 1928; Murray and Leonard 1962): The shells are solid and subrotund when young to subtriangular when old. Anterior and posterior ends are rounded. Posterior ridge is rounded. Beaks are slightly elevated and are directed forward; beak sculpture consists of several coarse, irregular ridges. Epidermis is yellowish-brown to chestnut. Cardinal teeth are heavy, triangular, divergent, and radially sulcated. Lateral teeth are short, thick, and straight. Beak cavities are moderately deep. The nacre is usually white, but may be orange or pinkish. Adults commonly 1 to 3 inches long.

Geographic Distribution: P. coccineum was found in the Osage River from its mouth to Bagnell Dam, the downstream 11.8 miles of Maries River, and the downstream 10.4 miles of Tavern Creek (Fig. 28). This species was common and locally abundant in the lower Osage River. Both past (Utterback 1915; 1917) and recent (Oesch in press) records reveal a wide distribution of P. coccineum in Missouri. In North America, P. coccineum is reported from the Upper Mississippi River Basin from southwestern New York to Kansas and Iowa, north to Wisconsin, south to Alabama and from the St. Lawrence River Basin (Burch 1973).

Habitat: P. coccineum occurred in an array of substrates from silt to coarse gravel, cobble and boulder, in 1 inch to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.0 ft./sec. at the bottom) water. Buchanan (1979; 1980) reported this species from silt to gravel, cobble and boulder substrates, in standing to moderately-flowing (1.5 ft./sec. at the bottom) water in 1 inch to 6 feet of water in the Meramec and Little Black river basins. It occurred most commonly in a gravel and cobble substrate in the Meramec Basin. It has been found in gravel or sand bottoms in a swift current in small streams to large rivers in other studies (Parmalee 1967; Murray and Leonard 1962; Goodrich and van der Schalie 1944).

Relative Abundance: In the lower Osage River Basin, P. coccineum comprised 2.8% of the living naiades found (Table 3). P. coccineum comprised 2.3% and 17.0%, respectively, in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is a common species in Missouri (Oesch in press), Illinois (Parmalee 1967), southeastern Kansas (Murray and Leonard 1962), and Indiana (Goodrich and van der Schalie 1944).

Breeding Season: Unknown.

Fish Host: Unknown.

Commercial Value: Illinois River specimens used for making novelties (Danglade 1914).

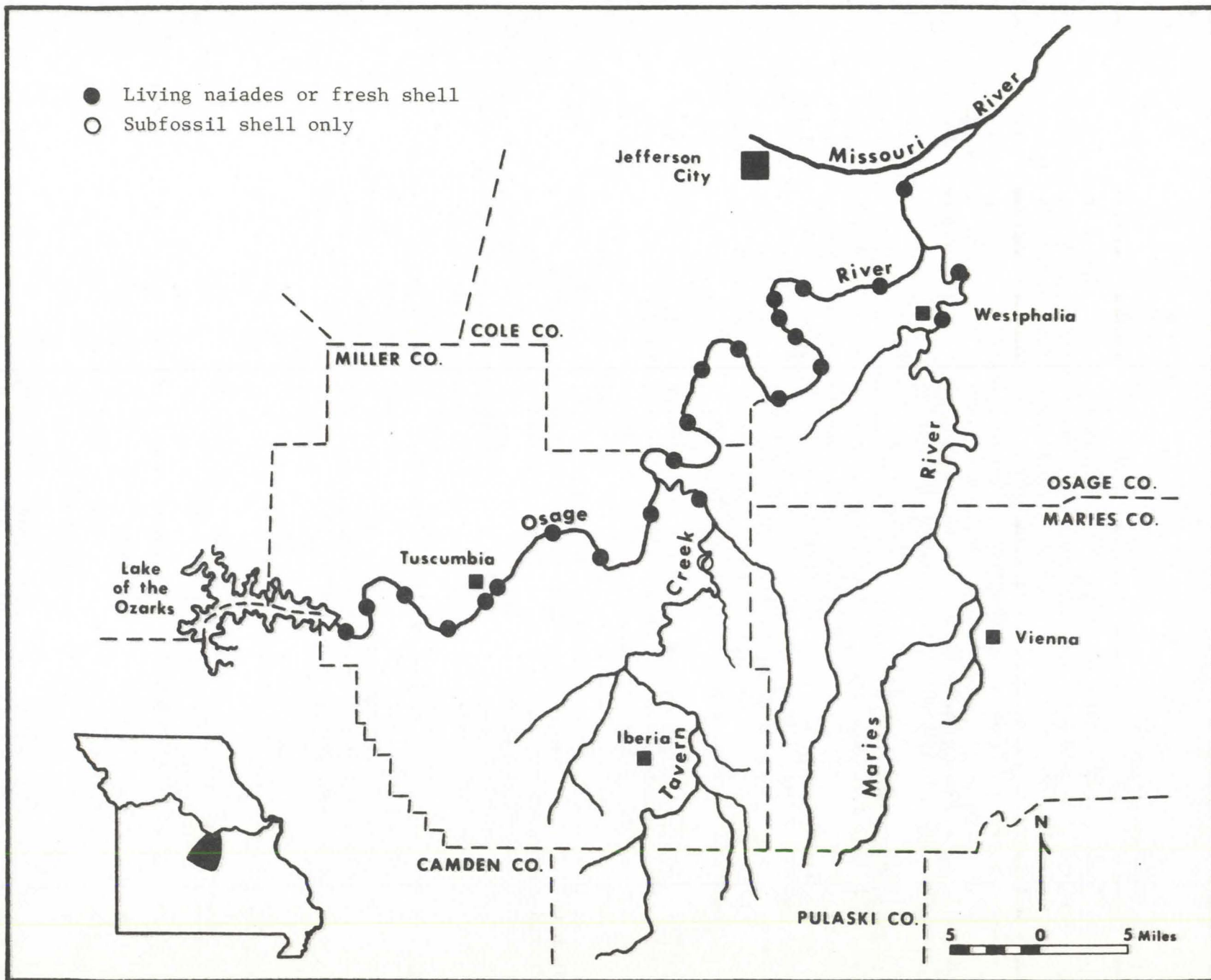


Figure 28. Distribution of Pleurobema coccineum (Conrad 1836) in the lower Osage River, Tavern Creek, and Maries River.

Elliptio crassidens crassidens (Lamarck 1819)

Elephant's Ear

Status: Endangered in Missouri (Missouri Department of Conservation 1977).

Physical Description (Parmalee 1967; Utterback 1915; Baker 1928): The shells are thick, heavy and solid, triangular and nearly rhomboid in shape. Anterior end is rounded and the posterior end is obliquely truncated with a prominent posterior ridge usually ending in a point. Beaks are large and flattened; beak sculpture consists of two to three coarse ridges parallel to the growth lines. Epidermis is reddish-brown to black. Cardinal teeth are triangular, massive, divergent, and rough. Lateral teeth are heavy and large. Beak cavities are shallow. Nacre is salmon to purple. Adults commonly 2 to 6 inches long.

Geographic Distribution: E. c. crassidens was found at only three sites in the lower Osage River; living specimens were found at only two sites (Fig. 29). None were found in Maries River or Tavern Creek. Early in this century, Utterback (1915; 1917) found this species in the Mississippi, Des Moines, and Meramec rivers and the Gasconade, and White river basins. More recently, outside of the Osage River, E. c. crassidens is known from only the Meramec and Castor rivers. In North America, E. c. crassidens is reported from the Mississippi River Basin, the Alabama-Coosa River system, the Black River system, Ohio River system, and the Amite River of Louisiana east to the St. Marys River system of Florida (Burch 1973; Johnson 1980).

Habitat: This species was found in a sand, gravel and cobble substrate, in 3 to 7 feet of water in slow (0.7 ft./sec. at the bottom) current. E. c. crassidens has been found on a stone and coarse gravel bottom in swift current, usually in large rivers by Parmalee (1967) and Baker (1928).

Relative Abundance: E. c. crassidens comprised less than 0.1% of the living naiades found in the lower Osage River Basin (Table 3). This species is extremely uncommon in Missouri. It is uncommon west of the Mississippi, but is abundant in large rivers east of the Mississippi (personal communication with Dr. David Stansbery, Director, Museum of Zoology, Ohio State University, Columbus, Ohio).

Breeding Season: Tachytictic (Utterback 1915).

Fish Host: Skipjack herring, Alosa chrysochloris (Fuller 1978).

Commercial Value: None.

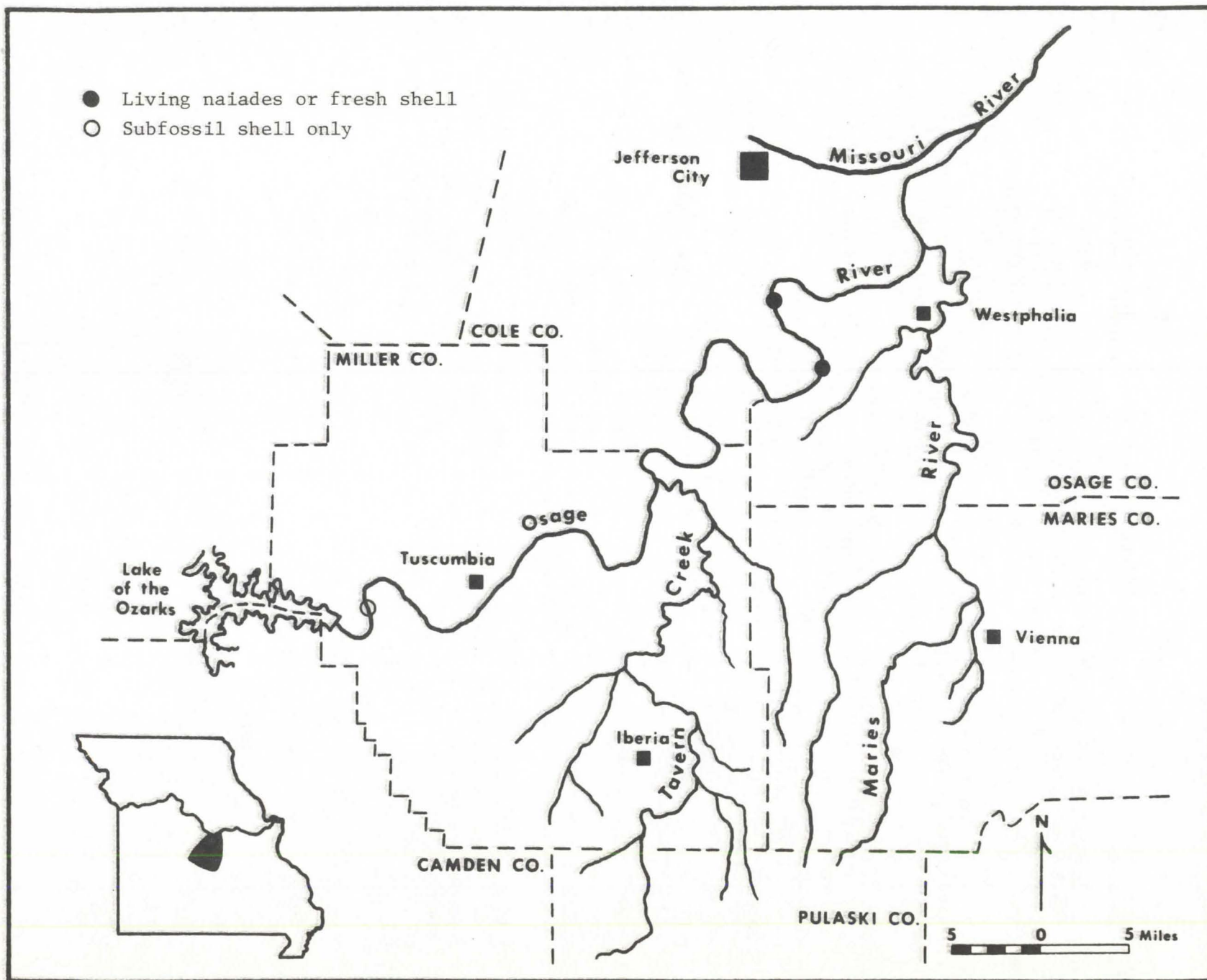


Figure 29. Distribution of Elliptio crassidens crassidens (Lamarck 1819) in the lower Osage River, Tavern Creek, and Maries River.

Elliptio dilatata (Rafinesque 1820)

Lady-Finger

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are compressed to slightly inflated and elongate-ellipsoid. Beaks are depressed and flattened; beak sculpture consists of four or five heavy bars, the first two subconcentric. Epidermis is usually brown to black. Cardinal teeth are low, triangular and rough. Lateral teeth are heavy; the right one is rough. Beak cavities are shallow to absent. Nacre may be white, orange, pink, or purple. Adults commonly 1 to 4 inches long.

Geographic Distribution: In the lower Osage River Basin, E. dilatata occurred between miles 10.3 and 80.8 in the Osage River, in the downstream 29.0 miles of Maries River, and in the downstream 20.4 miles of Tavern Creek (Fig. 30). This species was common and locally abundant in all three streams. E. dilatata is a common species throughout Missouri based on both past (Utterback 1915; 1917) and recent (Oesch in press) records. In North America, E. dilatata has been reported from the entire Mississippi River Basin, the St. Lawrence River system, the Alabama River system, southeast into Florida, and southwest to the Guadalupe River, Texas (Burch 1973).

Habitat: E. dilatata occurred in a range of substrates from silt to gravel, cobble and boulder, in 1 inch to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.0 ft./sec. at the bottom) water. Buchanan (1979; 1980) reported this species from silt to cobble and boulder substrates in 1 inch to 12 feet of water in standing to swiftly-flowing (1.7 ft./sec. at the bottom) water in the Meramec and Little Black river basins. Murray and Leonard (1962) found E. dilatata in soft mud, sand and mud, rock and sand, rock and mud, and sand and gravel bottoms in moderate to swift current.

Relative Abundance: E. dilatata comprised 2.6% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 6.9% and 11.4%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). E. dilatata is common and locally abundant in Missouri (Oesch in press), Illinois (Parmalee 1967), southeastern Kansas (Murray and Leonard 1962), Indiana (Goodrich and van der Schalie), Minnesota (Dawley 1947), and Wisconsin (Mathiak 1979).

Breeding Season: Tachytictic (Utterback 1915).

Fish Host: Gizzard shad, Dorosoma cepedianum; flathead catfish, Pylodictis olivaris; white crappie, Pomoxis annularis; black crappie, Pomoxis nigromaculatus; yellow perch, Perca flavescens (Fuller 1978).

Commercial Value: None.

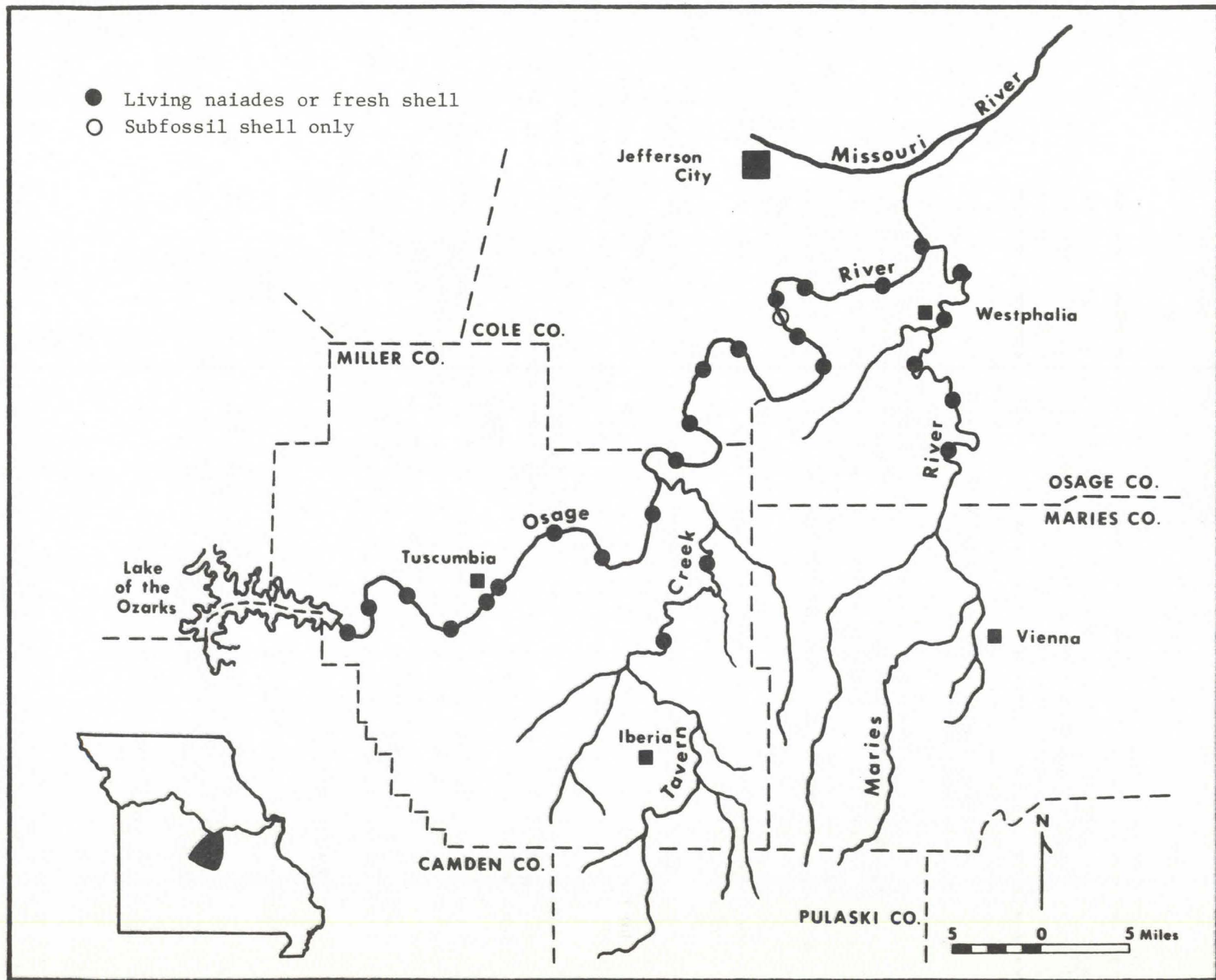


Figure 30. Distribution of *Elliptio dilatata* (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Obliquaria reflexa (Rafinesque 1820)

Three-Horned Warty-Back

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are solid, thick, inflated and oval. Anterior end is rounded and the posterior end is usually bluntly pointed and somewhat truncated. Posterior ridge is well developed. A row of three to five large rounded knobs is present from the beak to the center of the ventral margin; the knobs are alternate in position on opposite valves. Epidermis is yellow or yellowish-brown and smooth. Beaks are elevated and curved inward; beak sculpture consists of four or five heavy, parallel ridges which turn upward posteriorly. Cardinal teeth are heavy, elevated and ragged. Lateral teeth are straight, short, wide and serrated. Beak cavities are deep. Nacre is white. Adults commonly 1 to 2.5 inches long.

Geographic Distribution: O. reflexa was found in the lower Osage between its mouth and Bagnell Dam, in the downstream 11.8 miles of Maries River, and in the downstream 5.2 miles of Tavern Creek (Fig. 31). This species was nowhere abundant. Utterback (1915; 1917) found this species in the Platte, Marais des Cygnes, and Mississippi rivers, Crows Fork, and the Osage, White, and Gasconade river basins. More recently, it has been reported from the Little Black River (Buchanan 1979), the Meramec, Big, and Bourbeuse rivers (Buchanan 1980), and the St. Francis, Black, Salt, Gasconade, Sac, Pomme de Terre, Little Niangua, South Grand, Mississippi, Lamine, and Blackwater rivers and Horse Creek (Oesch in press). In North America, O. reflexa is known from the entire Mississippi River Basin from western Pennsylvania north into Ontario, Canada, southwest to eastern Kansas and Oklahoma and east into Georgia (Burch 1973).

Habitat: O. reflexa was found in a silt and sand to a sand, gravel, cobble and boulder substrate, in 2 inches to 10 feet of water in standing (0.0 ft./sec. at the bottom) to moderately-flowing (1.4 ft./sec. at the bottom) water. It occurred in similar habitats in the Meramec and Little Black river basins (Buchanan 1979; 1980). This species has been found on mud, sand, and gravel bottoms in small to large rivers in moderate to swift current in other studies (Parmalee 1967; Murray and Leonard 1962; Goodrich and van der Schalie 1944). This species is not found in headwaters.

Relative Abundance: O. reflexa comprised only 0.2% of the living naiades found in the lower Osage River Basin (Table 3). This species was also found in low numbers in the Meramec and Little Black river basins (Buchanan 1979; 1980). This is a common but rarely abundant species in Missouri (Oesch in press), Illinois (Parmalee 1967), Indiana (Goodrich and van der Schalie 1944), and Minnesota (Dawley 1947). O. reflexa is uncommon in Kansas (Murray and Leonard 1962) and Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Unknown.

Commercial Value: Of limited commercial value due to its small size (Stansbery 1973).

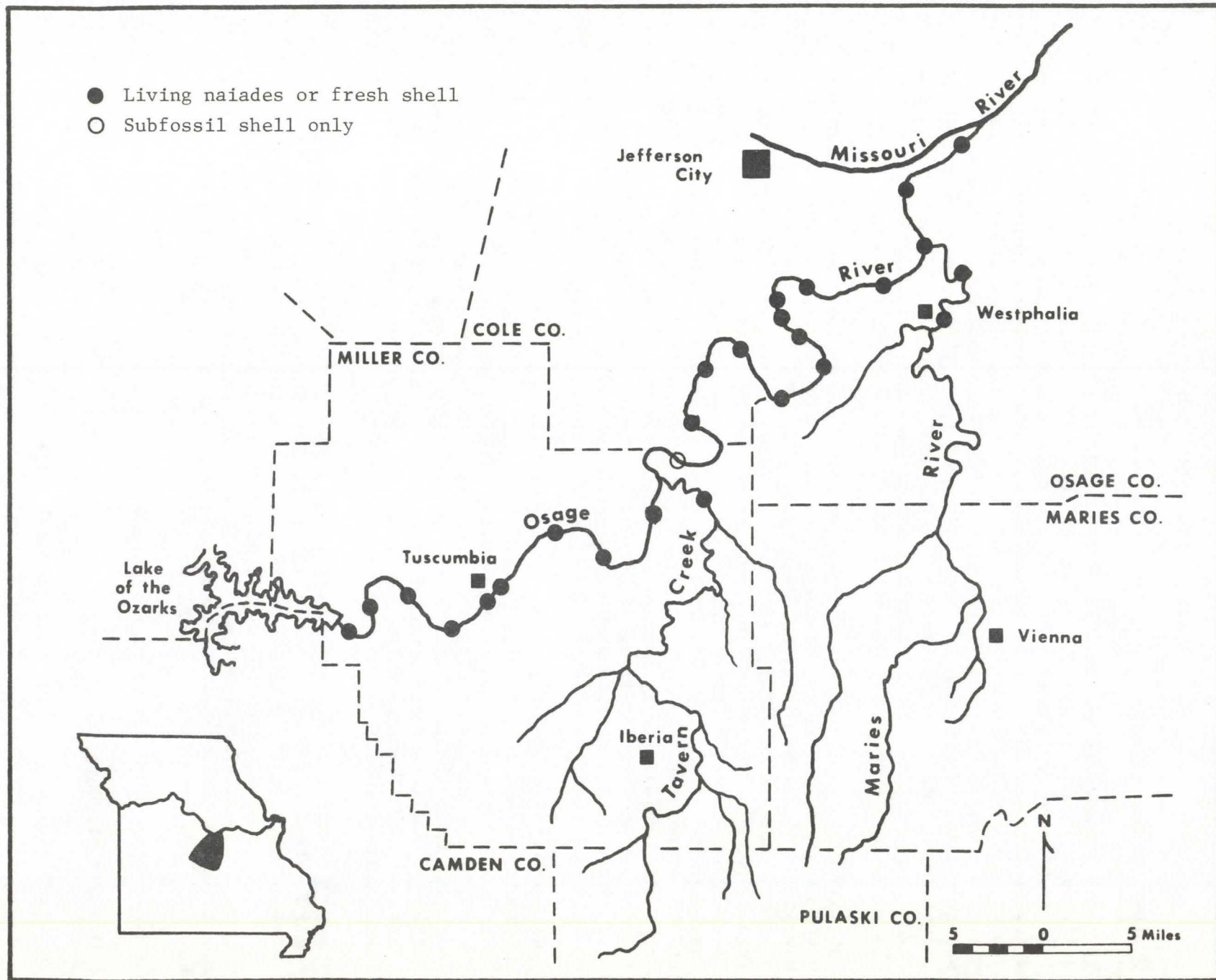


Figure 31. Distribution of Obliquaria reflexa (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Actinonaias ligamentina carinata (Barnes 1823)

Mucket

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are oblong to elliptical, solid, heavy, and moderately inflated. Beaks are rather low; beak sculpture consists of several fine bars, more or less double-looped. Epidermis is brown or yellowish. Cardinal teeth are heavy, triangular and serrated. Lateral teeth are long and heavy. Beak cavities are shallow. The nacre is white. Adults commonly 2 to 7 inches long.

Geographic Distribution: In the lower Osage River Basin A. l. carinata was found from Bagnell Dam to the mouth in the Osage River, but was found only in the downstream 4.9 miles of Maries River and downstream 6.8 miles of Tavern Creek (Fig. 32). In the past, Utterback (1915; 1917) reported this species from the Marais des Cygnes, Meramec, Osage, Gasconade, St. Francis, Mississippi, and Des Moines rivers and from the White and Black river basins. More recently, it has been reported from the Salt, Elk, Spring, James, St. Francis, Black, Gasconade, Big Piney, Whitewater, Little Niangua, and Pomme de Terre rivers (Oesch in press), the Little Black River (Buchanan 1979), and the Meramec, Big, and Bourbeuse rivers (Buchanan 1980). In North America, A. l. carinata is known from the Ohio-Mississippi River system, west to Kansas, north to Ontario and Manitoba, Canada, and south to Arkansas; from the St. Lawrence River Basin; Lake St. Clair; the Lake Erie drainage; the Niangua River system, and Lake Ontario (Parmalee 1967; Johnson 1980).

Habitat: A. l. carinata occurred in silt, sand and gravel to gravel, cobble and boulder substrate, in 1 inch to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.0 ft./sec. at the bottom) water. Buchanan (1979; 1980) found A. l. carinata in a range of substrates from silt to cobble and boulder in 1 inch to 12 feet of water in standing to swiftly-flowing (1.7 ft./sec. at the bottom) water in the Meramec and Little Black river basins. Other authors (Parmalee 1967; Murray and Leonard 1962; Goodrich and van der Schalie 1944) found this species on a coarse sand and gravel bottom, and less commonly on rock and muddy bottoms in small to large rivers in a swift current.

Relative Abundance: A. l. carinata comprised only 0.3% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 17.4% and 6.0%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is widespread and often abundant in Missouri and is common in Illinois (Parmalee 1967), Indiana (Goodrich and van der Schalie 1944), Minnesota (Dawley 1947), and Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Green sunfish, Lepomis cyanellus; bluegill, Lepomis macrochirus; largemouth bass, Micropterus salmoides; smallmouth bass, Micropterus dolomieu; white crappie, Pomoxis annularis; and seven other fish species (Fuller 1978).

Commercial Value: It was used in the shell button industry (Stansbery 1973).

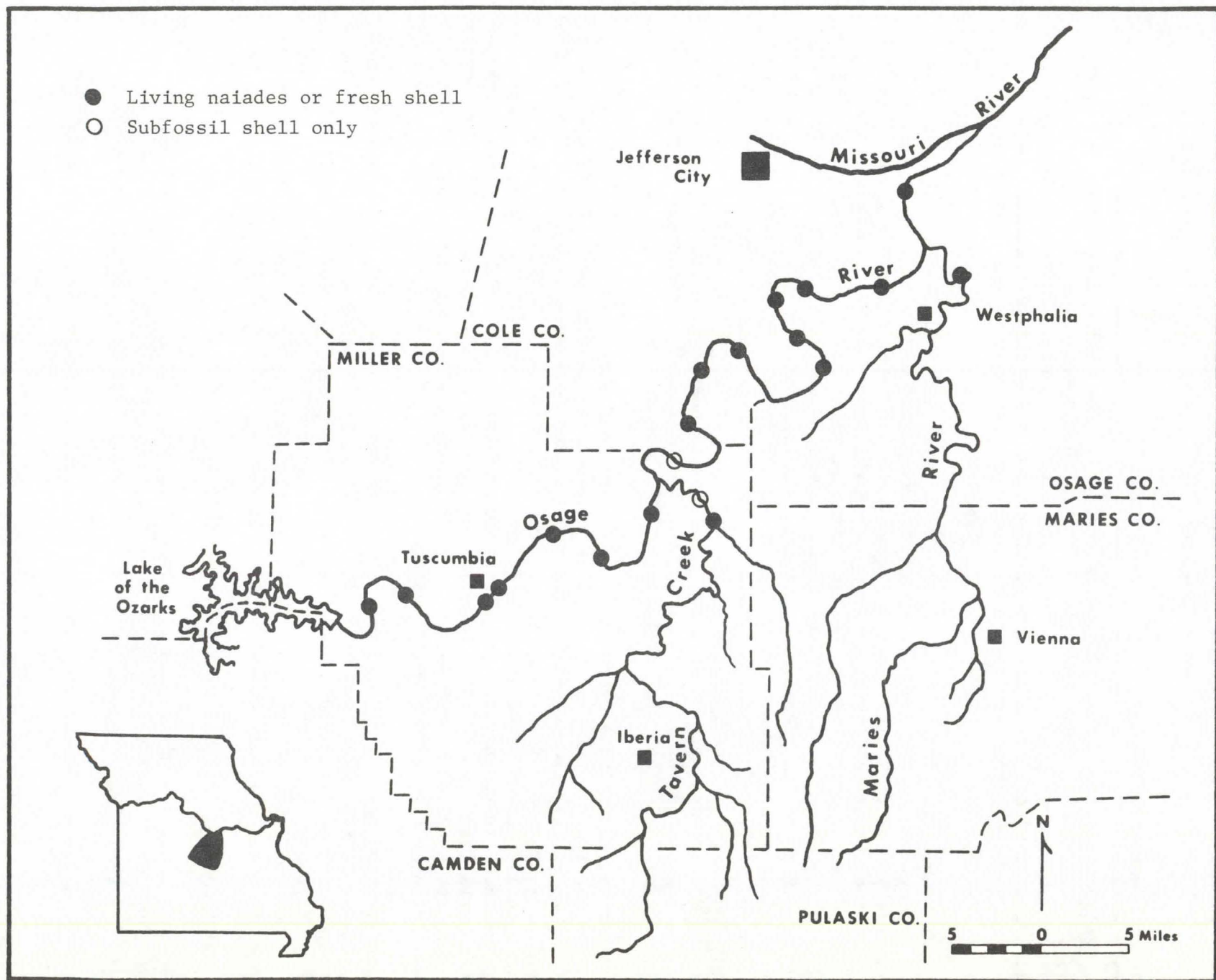


Figure 32. Distribution of Actinonaias ligamentina carinata (Barnes 1823) in the lower Osage River, Tavern Creek, and Maries River.

Venustaconcha ellipsiformis ellipsiformis (Conrad 1836)

Ellipse

Status: Unclassified.

Physical Description (Utterback 1915; Parmalee 1967; Baker 1928): The shells are small and elliptical. Anterior end is rounded; posterior end is bluntly pointed and the posterior ridge is rounded. Beaks are only slightly elevated above the hinge line and are usually eroded; beak sculpture consists of four faint double-looped bars. Epidermis is yellowish-brown with wavy rays. Cardinal teeth are strong, triangular and divergent. Lateral teeth are short, stout, slightly curved and sometimes rust-colored. Beak cavities are shallow. Nacre is white. Adults commonly 1 to 3 inches long.

Geographic Distribution: V. e. ellipsiformis occurred between miles 21.5 and 74.0 in the lower Osage River, in the downstream 32.1 miles of Maries River and throughout Tavern Creek (Fig. 33). It was common locally in all three streams. Utterback (1915; 1917) found this species in the Niangua and Gasconade rivers and in the Osage, Meramec, and White river basins. More recently, it has been reported to be wide-spread in the Osage River Basin and in southern Missouri streams (Oesch in press), and in the Meramec River Basin (Buchanan 1980). In North America, V. e. ellipsiformis has been reported from the Mississippi River system from western New York west to Iowa and Missouri, and from Wisconsin south to Arkansas, and from Red River of the North (Parmalee 1967; Johnson 1980).

Habitat: V. e. ellipsiformis was found in a sand to gravel, cobble and boulder substrate in 1 inch to 10 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.6 ft./sec. at the bottom) water. Buchanan (1979; 1980) found this species in similar habitats in the Meramec and Little Black river basins. In other studies this species has been typically found on a sand or gravel substrate, in swift current, in small rivers, and headwater streams in less than 1 foot of water (Parmalee 1967; Goodrich and van der Schalie 1944; Mathiak 1979).

Relative Abundance: V. e. ellipsiformis comprised only 0.6% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 3.1% and 0.2%, respectively, in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is common and locally abundant in Missouri (Oesch in press), northern Illinois (Parmalee 1967) and Indiana (Goodrich and van der Schalie 1944) and uncommon in Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Unknown.

Commercial Value: None.

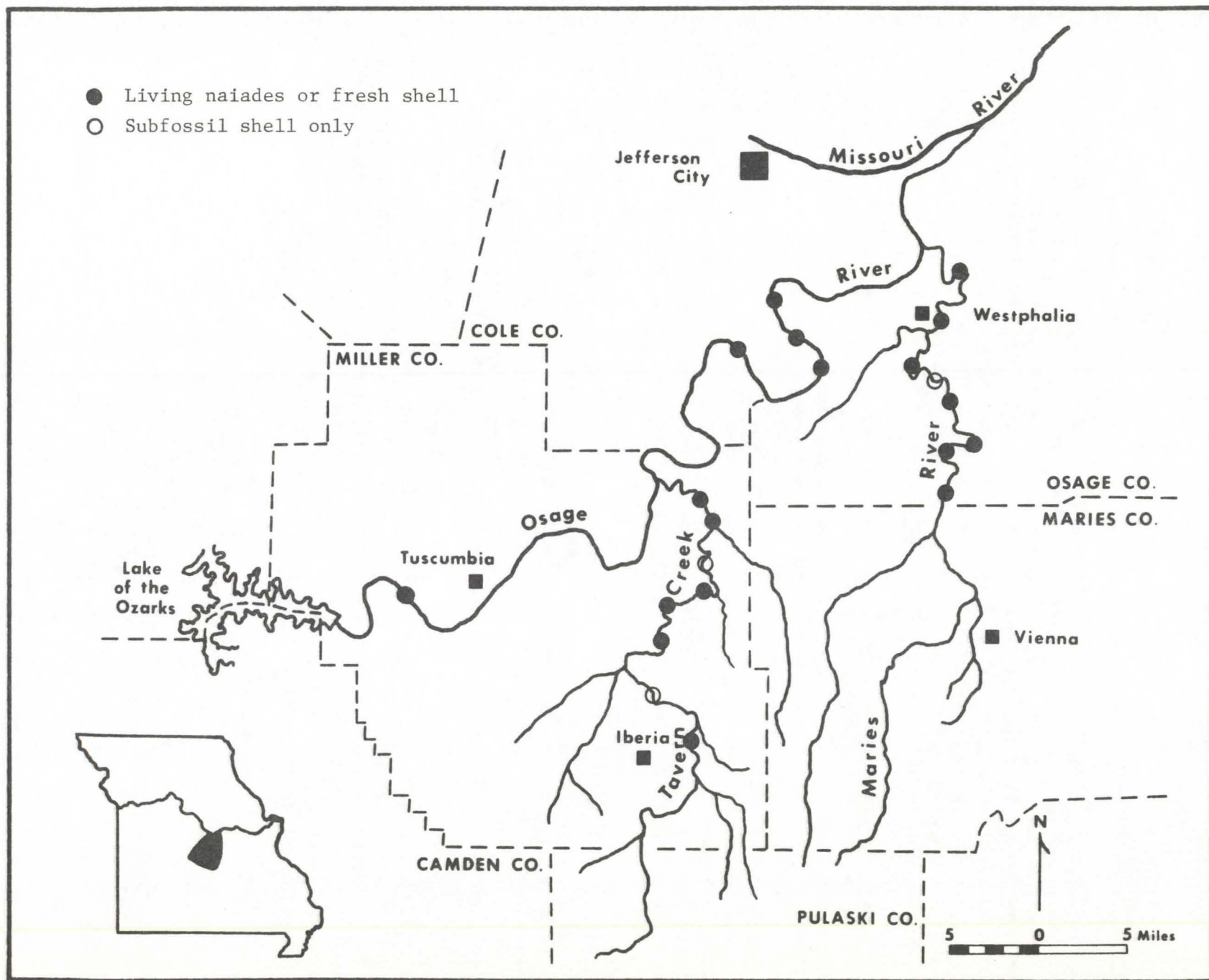


Figure 33. Distribution of Venustaconcha ellipsiformis ellipsiformis (Conrad 1836) in the lower Osage River, Tavern Creek, and Maries River.

Plagiola lineolata (Rafinesque 1820)

Butterfly

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are solid, heavy, compressed and somewhat triangular in outline. Anterior end is broadly rounded and the posterior end is bluntly pointed. Posterior ridge is prominent and sharply angled. Beaks are compressed and directed forward; beak sculpture consists of two or three fine, faint, double-looped bars. Epidermis is dull yellow or yellowish-green with rays broken into squarish or elongated spots. Cardinal teeth are heavy, low and triangular. Lateral teeth are straight, thick and short. Beak cavities are shallow. The nacre is white. Adults commonly 2 to 5 inches long.

Geographic Distribution: In the lower Osage River Basin, P. lineolata was found only in the Osage River where it was common but nowhere abundant (Fig. 34). Utterback (1915; 1917) reported this species from the Meramec, Marais des Cygnes, Mississippi, Osage and Gasconade rivers and the Blackwater and White river basins. More recently, it has been reported from the Salt, Gasconade, Sac, Pomme de Terre, and Mississippi rivers, the River Aux Vases and Horse Creek (Oesch in press), the Little Black River (Buchanan 1979), and the Meramec, Big, and Bourbeuse rivers (Buchanan 1980). In North America, P. lineolata has been reported from the Mississippi River Basin south to Arkansas, west to eastern Iowa, Kansas, and Texas, and in the Tombigbee and Alabama river basins (Burch 1973).

Habitat: P. lineolata occurred in a silt, sand and gravel, or sand, gravel, cobble and boulder substrate, in 3 inches to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.0 ft./sec. at the bottom) water. In the Meramec River Basin (Buchanan 1980) P. lineolata was found in a range of substrates from silt to cobble in 1 inch to 5 feet of water in standing to moderately-flowing (1.5 ft./sec. at the bottom) water. Other researchers (Parmalee 1967; Murray and Leonard 1962; Goodrich and van der Schalie 1944) found this species on sand and gravel bottoms, especially on bars in medium-sized and large rivers.

Relative Abundance: P. lineolata comprised only 0.5% of the living naiades found in the lower Osage River Basin (Table 3). P. lineolata also occurs in low numbers in the Meramec River Basin (Buchanan 1980). This is a common species in Missouri (Oesch in press), and in big rivers in Illinois (Parmalee 1967), and Indiana (Goodrich and van der Schalie 1944). It is uncommon in Kansas (Murray and Leonard 1962), Minnesota (Dawley 1947) and Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Freshwater drum, Aplodinotus grunniens; sauger, Stizostedion canadense; green sunfish, Lepomis cyanellus (Fuller 1978).

Commercial Value: Valuable for the pearl button and pearl culture industries (Stansbery 1973).

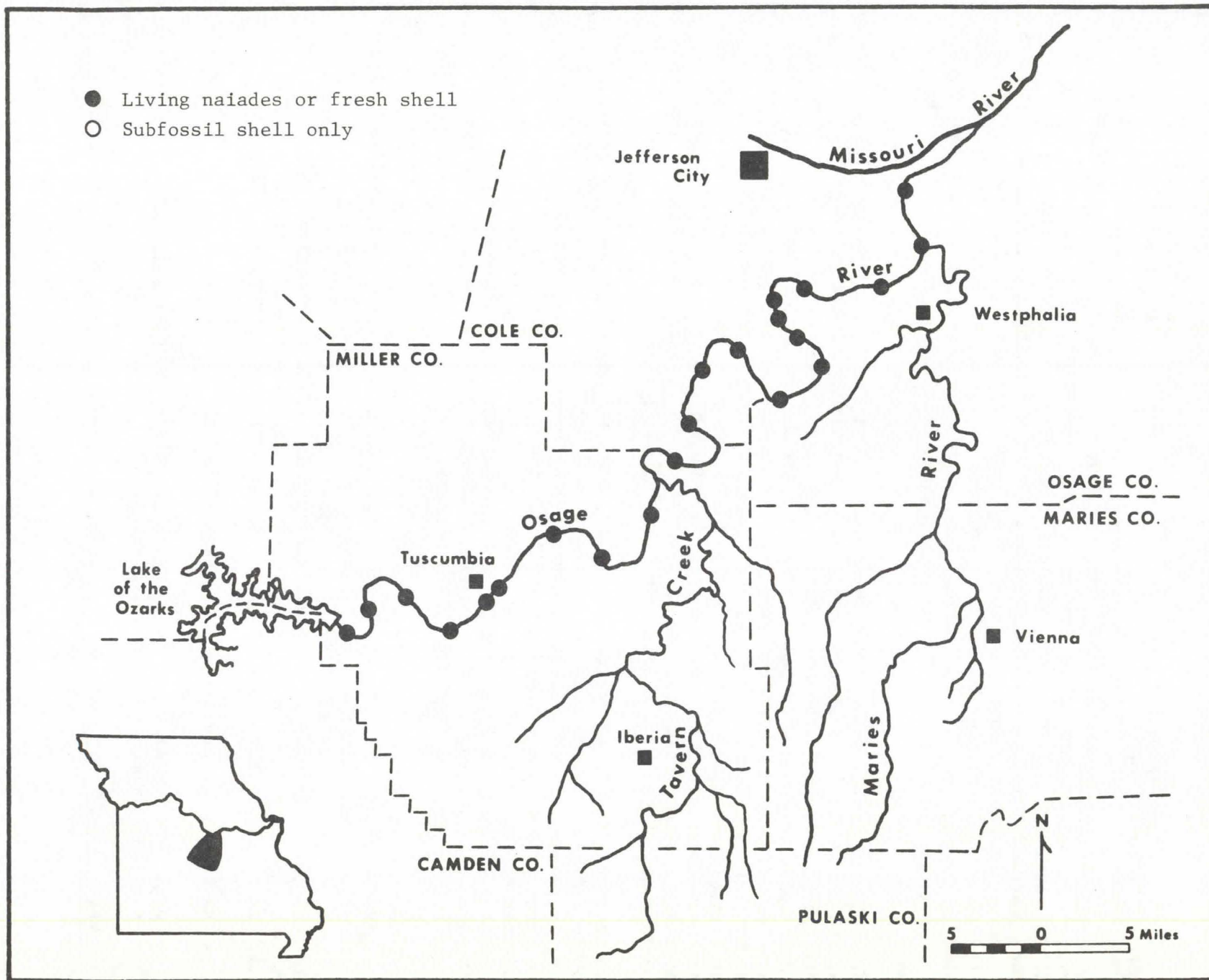


Figure 34. Distribution of Plagiola lineolata (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Obovaria olivaria (Rafinesque 1820)

Hickory-Nut

Status: Rare in Missouri (Missouri Department of Conservation 1977).

Physical Description (Baker 1928; Ortmann 1919): The shells are thick, heavy, ovate or elliptical, very oblique and inflated. Anterior end is rounded and the posterior end is rounded in females and pointed in males. Posterior ridge is rounded and indistinct. Beaks are swollen and curved inward and forward; beak sculpture consists of four to five fine, double-looped bars. Epidermis is yellow, olive-green or brown. Cardinal teeth are thick, roughened and stumpy or slightly elongated. Lateral teeth are long, heavy, and thick. Beak cavities are shallow. Nacre is white. Adults commonly 1 to 2 inches long.

Geographic Distribution: Living O. olivaria were not found in the lower Osage River Basin during this study; subfossil shell was found at five sites (Fig. 35). This species has not been reported previously from the lower Osage River. In the past, Utterback (1915; 1917) found this species in the Osage, Grand, Mississippi, and Des Moines rivers and in the White River Basin. More recently, it has been reported from the Mississippi, Salt, and South Grand rivers (Oesch in press). In North America, O. olivaria is found in the Upper Mississippi and Ohio river basins from western New York west to Kansas, Iowa, and Missouri, north to Minnesota and Quebec, Canada, and south to Arkansas, Tennessee and northern Alabama (Parmalee 1967).

Habitat: It is typically found on sand and gravel bottoms in a moderate to swift current in medium-sized to large rivers (Goodrich and van der Schalie 1944).

Relative Abundance: No living O. olivaria were found in the lower Osage River Basin. O. olivaria is uncommon in Missouri (Oesch in press) and Minnesota (Dawley 1947), but is locally abundant in large rivers in Illinois (Parmalee 1967) and locally common in large rivers in Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Shovelnose sturgeon, Scaphirhynchus platyrhynchus (Coker et al. 1921).

Commercial Value: Unknown.

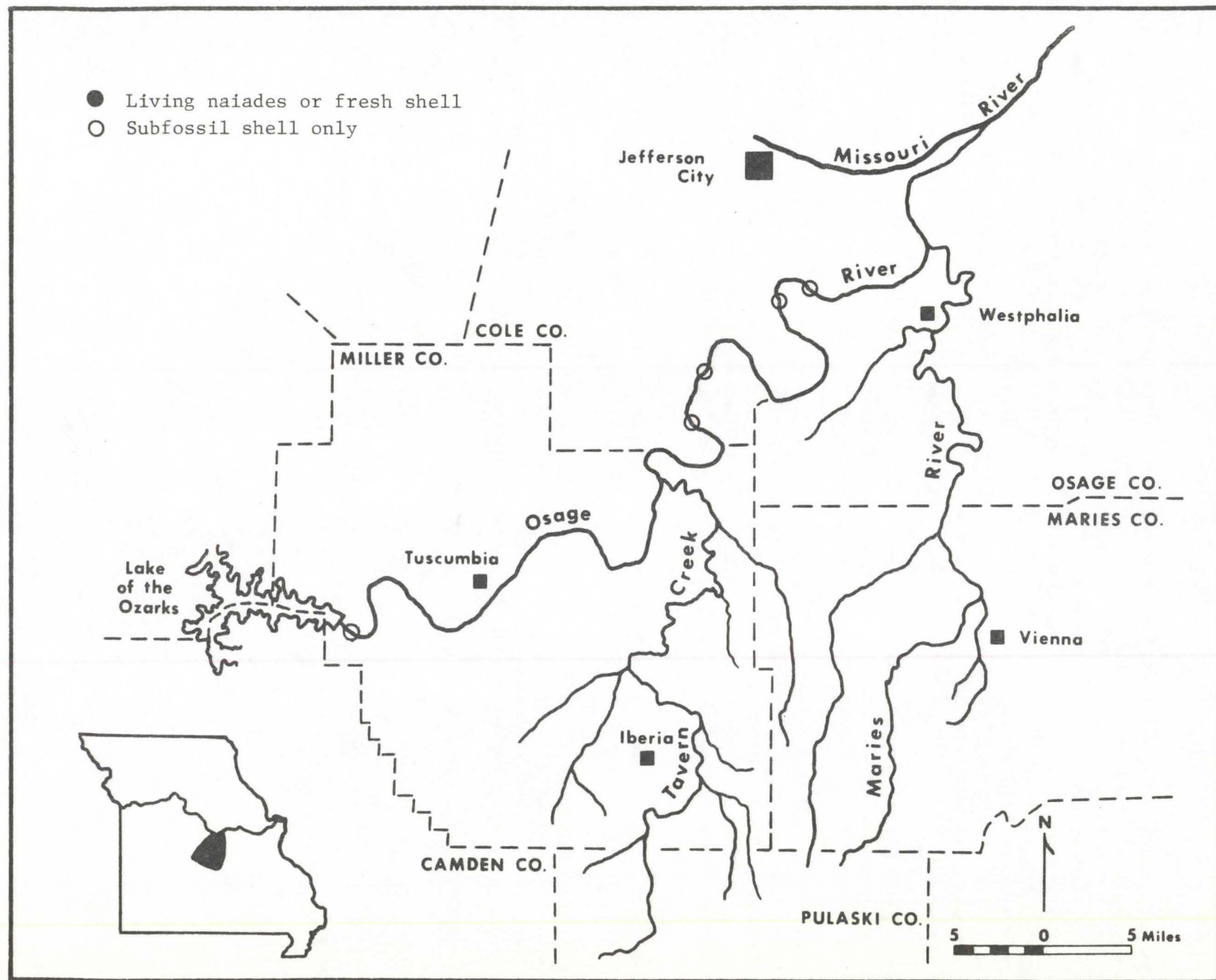


Figure 35. Distribution of *Obovaria olivaria* (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Truncilla truncata (Rafinesque 1820)

Deer-Toe

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are triangular in outline, thick, solid and moderately inflated. Anterior end is rounded and the posterior end is pointed and obliquely truncated. Posterior ridge is prominent and sharply angled. Beaks are full, incurved and elevated; beak sculpture consists of three to four fine bars, the first subconcentric, the rest double-looped. Epidermis is greenish, yellowish or yellowish-brown with numerous green rays in a zig-zag pattern. Cardinal teeth are triangular, compressed, elevated and serrated. Lateral teeth are thin and elevated. Beak cavities are shallow. Nacre is white. Adults commonly 1 to 2 inches long.

Geographic Distribution: In the lower Osage River Basin, T. truncata was found in the downstream 16.8 miles of Maries River, in the downstream 10.4 miles of Tavern Creek, and in the Osage River between its mouth and Bagnell Dam (Fig. 36). Utterback (1917) found T. truncata in the Mississippi River and the Osage, Gasconade, Meramec, and White river basins. More recently, Oesch (in press) found this species to be widespread on the north slope of the Ozarks and in south central and southeastern Missouri. In North America, T. truncata has been reported from throughout the Mississippi River Basin from western Pennsylvania to Michigan and Minnesota south to Iowa, eastern Kansas and Texas and northern Alabama and Tennessee (Burch 1973).

Habitat: T. truncata was found in a sand, gravel and cobble or gravel and cobble substrate in 1 inch to 10 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.0 ft./sec. at the bottom) water. Buchanan (1979; 1980) reported it from a silt to cobble and boulder substrate, in standing to moderately-flowing (1.5 ft./sec. at the bottom) water in 1 inch to 5 feet of water in the Meramec and Little Black river basins. Other authors (Murray and Leonard 1962; Goodrich and van der Schalie 1944; Parmalee 1967) reported this species from nearly all substrate types in small to large rivers in a moderate to swift current.

Relative Abundance: T. truncata comprised only 0.3% of the living naiades found in the lower Osage River Basin (Table 3). This species was also found in low numbers in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is a common species in Missouri (Oesch in press), Illinois (Parmalee 1967), southeastern Kansas (Murray and Leonard 1962), parts of Indiana (Goodrich and van der Schalie 1944), and in large rivers in Minnesota (Dawley 1947).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Sauger, Stizostedion canadense; freshwater drum, Aplodinotus grunniens (Fuller 1978).

Commercial Value: None.

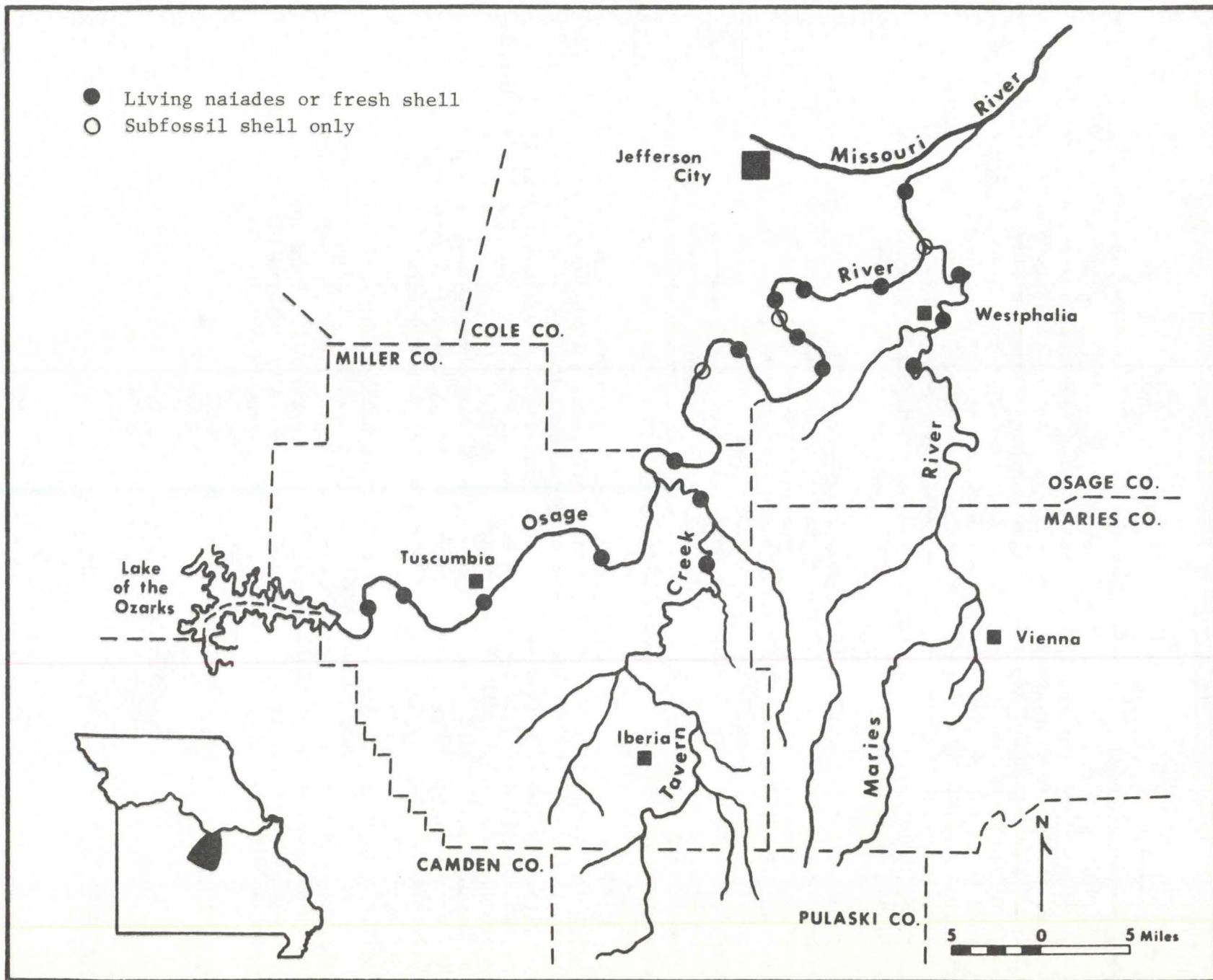


Figure 36. Distribution of *Truncilla truncata* (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Truncilla donaciformis (Lea 1827)

Fawn's Foot

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are small, elongate-ovate, thin but strong and compressed to moderately inflated. Anterior end is bluntly pointed. Posterior ridge is prominent. Beaks are full and elevated slightly above the hinge line; beak sculpture consists of three to four fine bars, the first almost concentric and the rest double-looped. Epidermis is greenish or yellowish with numerous wide dark green rays broken up into zig-zag lines. Cardinal teeth are thin, compressed and divergent. Lateral teeth are thin, nearly straight and elevated. Beak cavities are shallow. The nacre is bluish-white to white. Adults commonly 1 to 2 inches long.

Geographic Distribution: T. donaciformis was found at only four sites in the lower Osage River and living specimens were found at only two sites (Figure 37). None were found in Maries River or Tavern Creek. Utterback (1917) found this species in the Mississippi and Des Moines rivers and in the Grand, Platte, Osage, Meramec, and Gasconade river basins. More recently, Oesch (in press) reported T. donaciformis from the St. Francis, Black, Cuivre, Salt, Gasconade, Sac, Pomme de Terre, Little Niangua, Niangua, Spring, Wyaconda, South Grand, Mississippi, Loutre, and Blackwater rivers and Grindstone and Horse creeks. It is also known from the Meramec, Big, and Bourbeuse rivers (Buchanan 1980) and the Little Black River (Buchanan 1979). In North America, T. donaciformis is found generally throughout the Mississippi River Basin from western Pennsylvania to eastern Kansas, north to Minnesota, and south to eastern Texas, and east to Louisiana and Alabama (Burch 1973).

Habitat: This species was found in a silt substrate in slow current (less than 0.2 ft./sec. at the bottom) in the lower Osage River. It was found in a silt, sand, gravel and cobble, or gravel, cobble and boulder substrate in 1 inch to 5 feet of water in standing to swiftly-flowing water in the Meramec and Little Black river basins (Buchanan 1979; 1980). T. donaciformis has been found on a mud, sand, gravel or rocky bottom in river-lakes, and small to large rivers in slow to swift current (Baker 1928; Murray and Leonard 1962; Goodrich and van der Schalie 1944; Parmalee 1967). This species occurs most commonly in large river habitats.

Relative Abundance: T. donaciformis comprised less than 0.1% of the living naiades found in the lower Osage River Basin (Table 3). This species also comprised 0.1% or less of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is common in Missouri (Oesch in press), Illinois (Parmalee 1967), and southeastern Kansas (Murray and Leonard 1962), and is uncommon in Indiana (Goodrich and van der Schalie 1944), Minnesota (Dawley 1947), and Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Freshwater drum, Aplodinotus grunniens; sauger, Stizostedion canadense (Parmalee 1967).

Commercial Value: None.

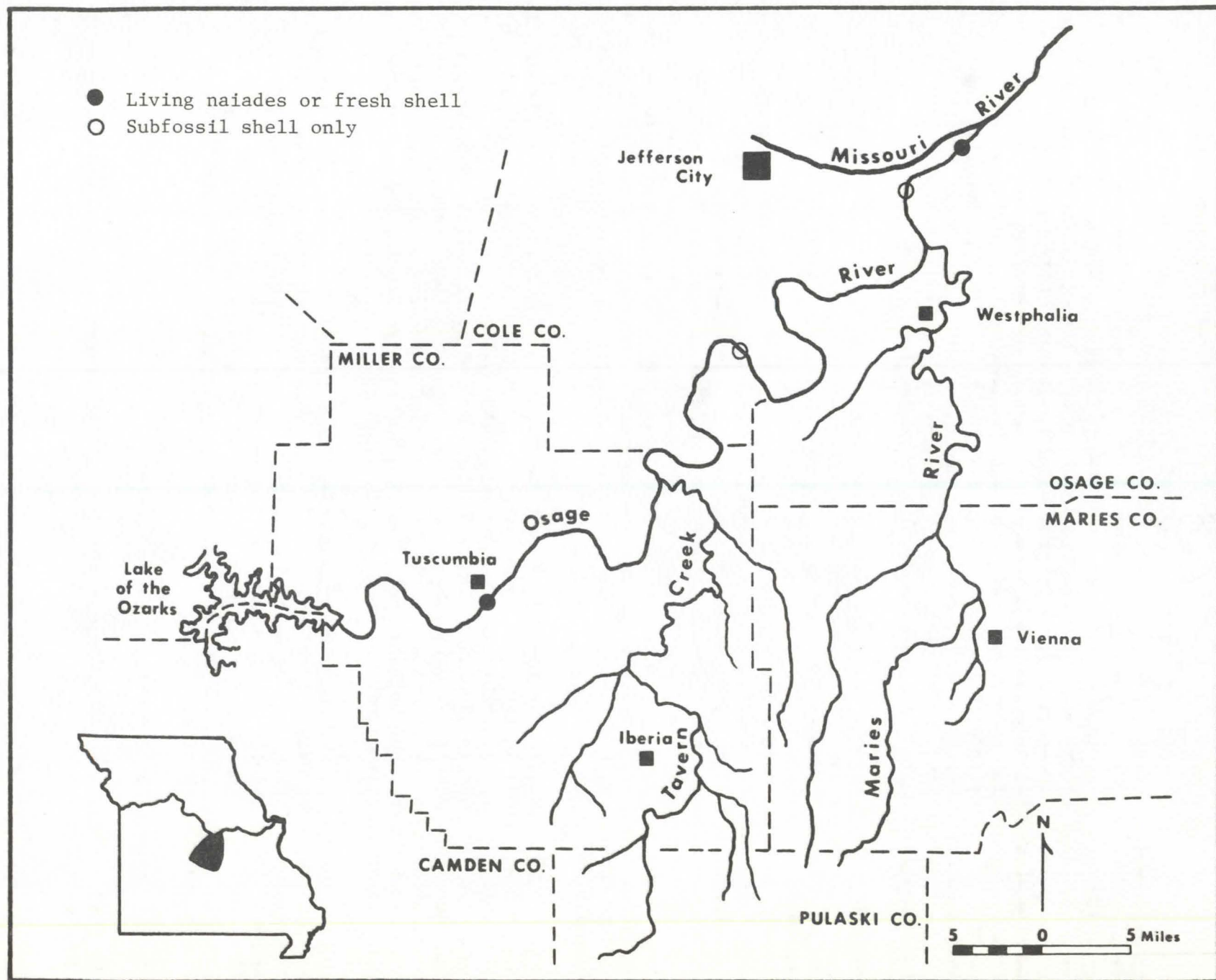


Figure 37. Distribution of Truncilla donaciformis (Lea 1827) in the lower Osage River, Tavern Creek, and Maries River.

Leptodea fragilis (Rafinesque 1820)

Fragile Paper-Shell

Status: Unclassified.

Physical Description (Baker 1928; Ortmann 1919): The shells are large, thin, brittle, compressed, subelliptical to subovate and alate posterior-dorsally. Anterior end is rounded and the posterior end is obliquely truncated. Posterior ridge is indistinct. Beaks are flattened; beak sculpture consists of three to four fine bars, the first concentric, the others double-looped. Epidermis is smooth, yellow to light brown and rayed or not. Growth lines are conspicuous. Cardinal teeth are small, thin and compressed. Lateral teeth are long, thin and compressed. Beak cavities are shallow. Nacre is white or iridescent pinkish to bluish. Adults commonly 2 to 6 inches long.

Geographic Distribution: L. fragilis was widely distributed in the lower Osage River and Tavern Creek and in the downstream half of Maries River (Fig. 38), but it was nowhere abundant. Utterback (1915; 1917) found L. fragilis in all of Missouri except south Missouri. More recently, Oesch (in press) found this species in all parts of Missouri. In North America, L. fragilis is known from the entire Mississippi River Basin from New York to Kansas and south to Texas, Mississippi and Alabama, north to Wisconsin and Minnesota, and from the St. Lawrence River drainage and the Hudson River (Burch 1973).

Habitat: L. fragilis was found in an array of substrates from silt to coarse gravel, cobble and boulder, in 1 inch to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.6 ft./sec. at the bottom) water. This species was collected in similar habitats in the Meramec and Little Black river basins (Buchanan 1979; 1980). It has been found on mud, sand, and rocky bottoms in slow or standing water in small to large rivers and river-lakes by other researchers (Murray and Leonard 1962; Parmalee 1967; Goodrich and van der Schalie 1944).

Relative Abundance: L. fragilis comprised 0.6% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 0.5% and 0.1%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979, 1980). It is common and widespread in Missouri (Oesch in press), Illinois (Parmalee 1967), southeastern Kansas (Murray and Leonard 1962), Indiana (Goodrich and van der Schalie 1944), and big river habitat in Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Baker 1928).

Fish Host: Freshwater drum, Aplodinotus grunniens (Fuller 1978).

Commercial Value: None.

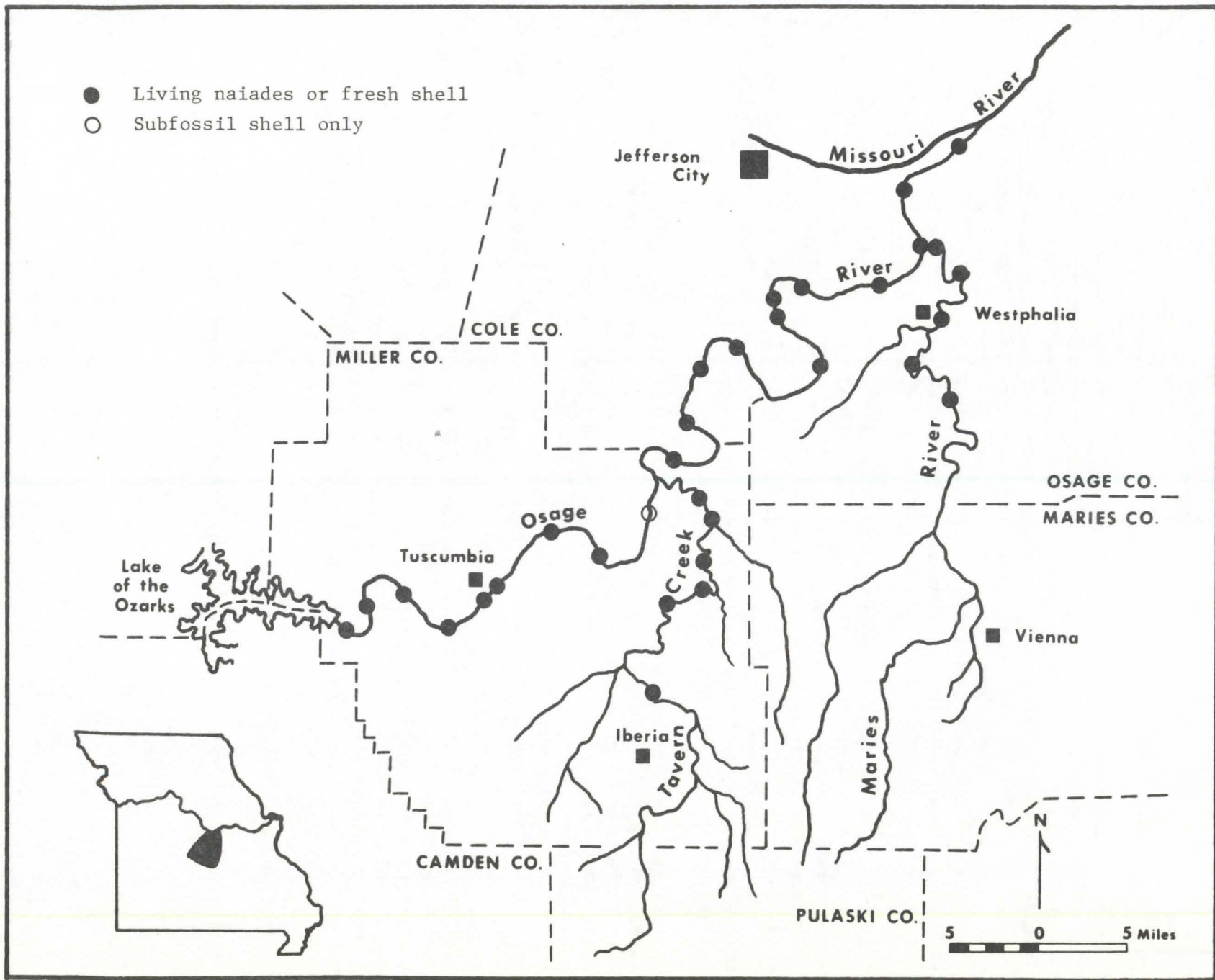


Figure 38. Distribution of *Leptodea fragilis* (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Potamilus alatus (Say 1817)

Pink Heel-Splitter

Status: Unclassified.

Physical Description (Baker 1928; Parmalee 1967): The shells are thin to thick, often large, compressed to moderately inflated, triangular in outline and alate posteriorly. Shells are rounded anteriorly and obliquely truncated posteriorly. Posterior ridge is rounded. Beaks are flattened; beak sculpture consists of three to four faint bars, all except the first double-looped. Epidermis is dark brownish-green to black. Cardinal teeth are compressed, small and triangular. Lateral teeth are long and thin. Beak cavities are shallow. Nacre is pearly-white to purple, but usually purple. Adults commonly 2 to 8 inches long.

Geographic Distribution: P. alatus was the most widespread species found in the lower Osage River Basin and occurred in all of the basin except the upper reaches of Maries River (Fig. 39). P. alatus occurred at 40 of the 43 sites sampled in the lower Osage River Basin. Early in this century, Utterback (1915; 1917) found P. alatus in all of Missouri except south Missouri. Oesch (in press) reported a somewhat similar recent distribution of this species in Missouri. P. alatus is found throughout the Mississippi River Basin south to Arkansas, Tennessee, and northern Alabama, in the St. Lawrence drainage, and in parts of Red River of the North and the Winnipeg River (Burch 1973).

Habitat: P. alatus occurred in all substrates except shifting sand, in 1 inch to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.6 ft./sec. at the bottom) water. It was found in similar habitat in the Meramec River Basin (Buchanan 1980). P. alatus was found in lakes, ponds, river-lakes, and small to large rivers in slow to swift current on a mud, gravel or rocky bottom by other investigators (Parmalee 1967; Goodrich and van der Schalie 1944; Murray and Leonard 1962).

Relative Abundance: In the lower Osage River Basin, P. alatus comprised 2.3% of the living naiades found (Table 3). It also comprised 2.3% of the living naiades found in the Meramec River Basin (Buchanan 1980). P. alatus is common in Missouri (Oesch in press), southern Illinois (Parmalee 1967), eastern Kansas (Murray and Leonard 1962) and Indiana (Goodrich and van der Schalie 1944), and uncommon in Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Freshwater drum, Aplodinotus grunniens (Fuller 1978).

Commercial Value: None.

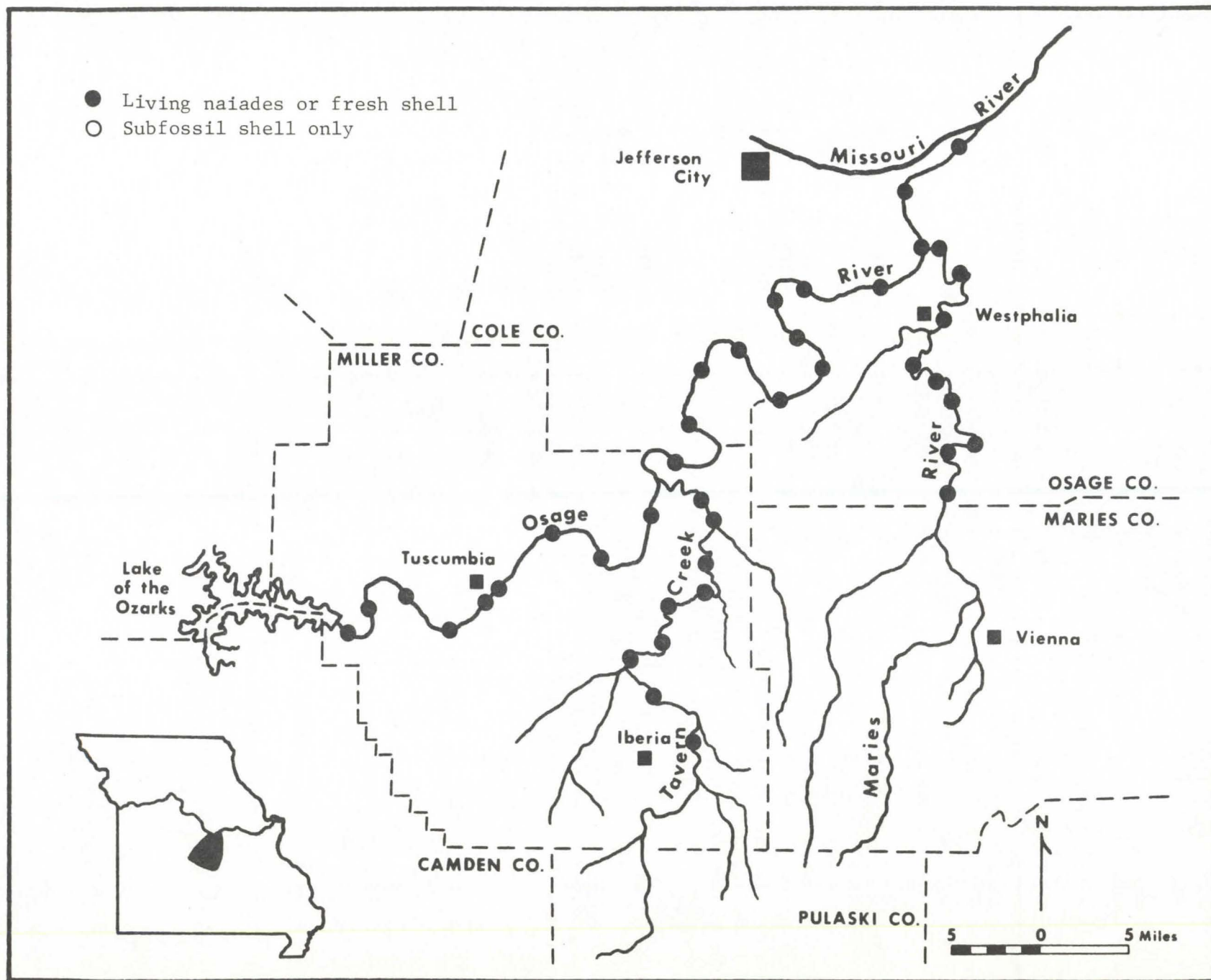


Figure 39. Distribution of Potamilus alatus (Say 1817) in the lower Osage River, Tavern Creek, and Maries River.

Potamilus ohiensis (Rafinesque 1820)

Fragile Heel-Splitter

Status: Unclassified.

Physical Description (Baker 1928; Utterback 1915): The shells are elliptical, compressed, thin and have a high, triangular, posterior wing and a small anterior wing. Beaks are compressed and flattened; beak sculpture consists of several small nodulous broken ridges. Anterior and posterior ends are rounded. Posterior ridge is rounded. Epidermis is yellowish or olive-green. Cardinal teeth are feeble, thin and erect. Lateral teeth are long, thin and elevated. Beak cavities are shallow. The nacre is purple. Adults commonly 1.5 to 6 inches long.

Geographic Distribution: P. ohiensis was found at only four sites in the downstream half of the Osage River and at one site in the downstream 1.4 miles of Maries River (Fig. 40). None were found in Tavern Creek. Early in this century, Utterback (1915; 1917) found this species in northwest Missouri lakes, the Platte, Mississippi and Des Moines rivers and the Grand, Chariton, Nodaway, Tarkio, Meramec, and Gasconade river basins. More recently, this species has been reported from the St. Francis, Salt, Gasconade, Pomme de Terre, North Fabius, South Grand, Mississippi, Lamine, Loutre, and Grand rivers, the River Aux Vases and Horse Creek (Oesch in press), and in the Big, Bourbeuse, and Meramec rivers (Buchanan 1980). In North America, P. ohiensis has been reported from the entire Mississippi River Basin, from New York to Minnesota; south to eastern Texas and Louisiana (Burch 1973).

Habitat: P. ohiensis was found in a silt to silt, sand, gravel, cobble and boulder substrate, in 1 to 3 feet of water in standing water (0.0 ft./sec. at the bottom). Buchanan (1980) reported it from a silt substrate, in 1 inch to 3 feet of water in standing water in the Meramec River Basin where this species occurred in only large river habitat. Baker (1928) stated that this species is found in large rivers with a swift current on a mud and sand bottom.

Relative Abundance: P. ohiensis comprised only 0.2% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 0.1% of the living naiades found in the Meramec River Basin (Buchanan 1980). It is uncommon in Missouri (Oesch in press), Indiana (Goodrich and van der Schalie 1944), Minnesota (Dawley 1947) and Wisconsin (Mathiak 1979), but is common in eastern Kansas (Murray and Leonard 1962) and in medium to large rivers in Illinois (Parmalee 1967).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: White crappie, Pomoxis annularis; freshwater drum, Aplodinotus grunniens (Fuller 1978).

Commercial Value: None.

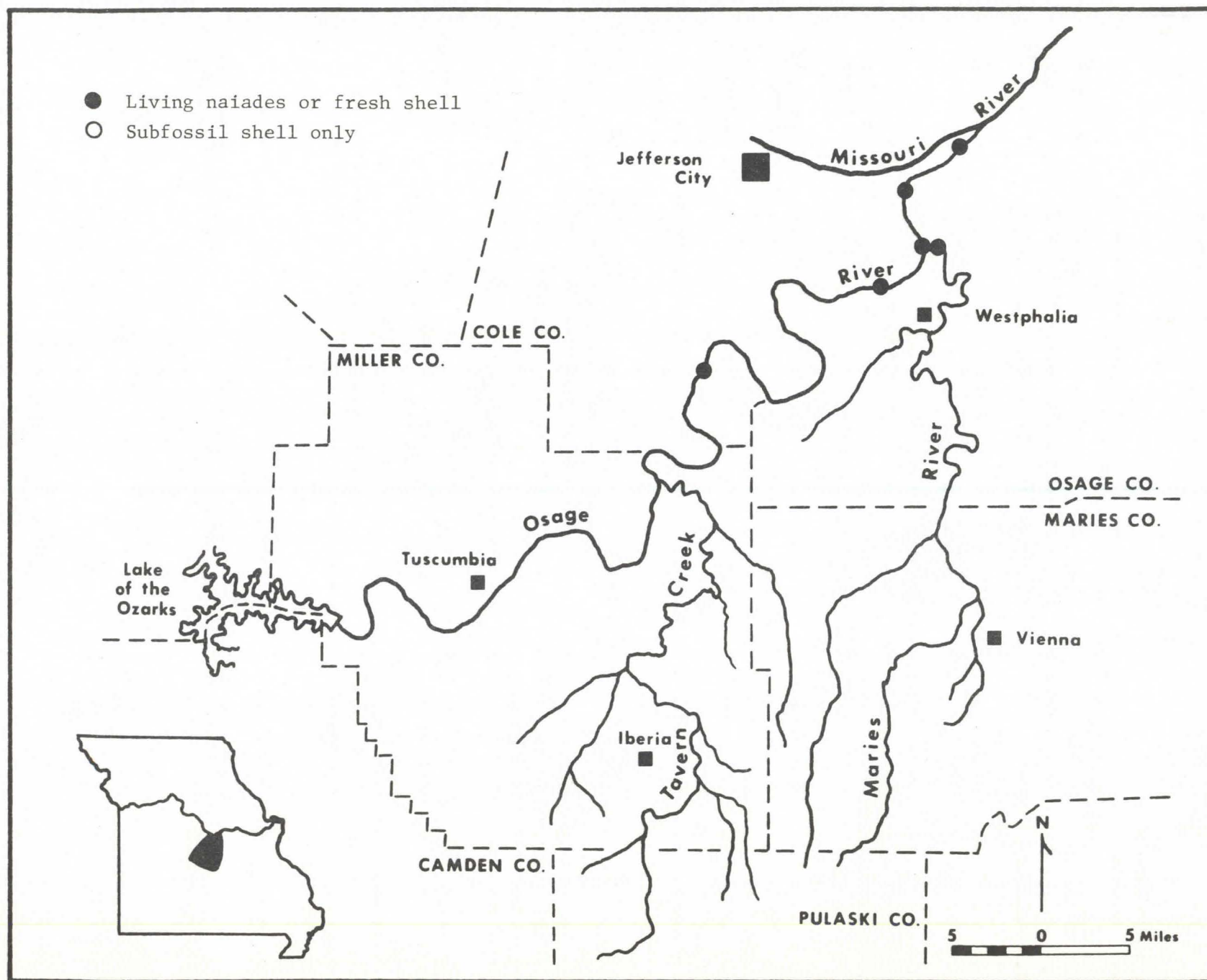


Figure 40. Distribution of Potamilus ohiensis (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Ligumia recta (Lamarck 1819)

Black Sand-Shell

Status: Unclassified

Physical Description (Baker 1928; Parmalee 1967): The shells are elongate, heavy, solid, large and compressed. Anterior end is rounded and the posterior end is pointed. Dorsal and ventral margins are nearly straight. Posterior ridge is rounded. Beaks are low; beak sculpture consists of three to five faint double-looped bars which disappear on the posterior slope. Epidermis is dark green to black and rayed when young. Cardinal teeth are triangular, compressed, serrated and divergent. Lateral teeth are long, straight and elevated. Beak cavities are shallow. Nacre is purple to white. Adults commonly 3 to 7 inches long.

Geographic Distribution: In the lower Osage River Basin, L. recta occurred in the Osage River between its mouth and Bagnell Dam, in the downstream 23.7 miles of Tavern Creek, and in the downstream 11.8 miles of Maries River (Fig. 41). This species was common but nowhere abundant. Early in this century, Utterback (1915; 1917) found L. recta in the Black, Osage, White, Gasconade, Mississippi and Des Moines rivers, and the Platte, Neosho, Meramec, Blackwater, and St. Francis river basins. More recently, Oesch (in press) found this species in the above rivers and in Salt River. L. recta is also found in the Little Black River (Buchanan 1979) and the Meramec, Big, and Bourbeuse rivers (Buchanan 1980). In North America, L. recta has been reported from throughout the Mississippi River Basin, from the Alabama River Basin north to Minnesota; from the St. Lawrence River system, Red River of the North, and Lakes Huron, St. Clair, Erie, and Ontario (Burch 1973; Johnson 1980).

Habitat: L. recta was found in an array of substrates from silt to coarse gravel, cobble and boulder, in 2 inches to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.0 ft./sec. at the bottom) water. Buchanan (1979; 1980) reported this species from similar habitats in the Meramec and Little Black river basins. This species was found on sand and gravel bottoms in lakes and in small to large rivers with a swift current (Parmalee 1967; Goodrich and van der Schalie 1944).

Relative Abundance: L. recta comprised 0.5% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 0.8% and 0.1%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is a common species in Missouri (Oesch in press), Illinois (Parmalee 1967), Indiana (Goodrich and van der Schalie 1944), Minnesota (Dawley 1947) and Wisconsin (Mathiak 1979), but is uncommon in Kansas (Murray and Leonard 1962).

Breeding Season: Bradytictic (Baker 1928).

Fish Host: Bluegill, Lepomis macrochirus; white crappie, Pomoxis annularis; American eel, Anguilla rostrata; largemouth bass, Micropterus salmoides; sauger, Stizostedion canadense (Fuller 1978).

Commerical Value: Used as a source of inlay material for pearly-handled knives and similar objects (Stansbery 1973).

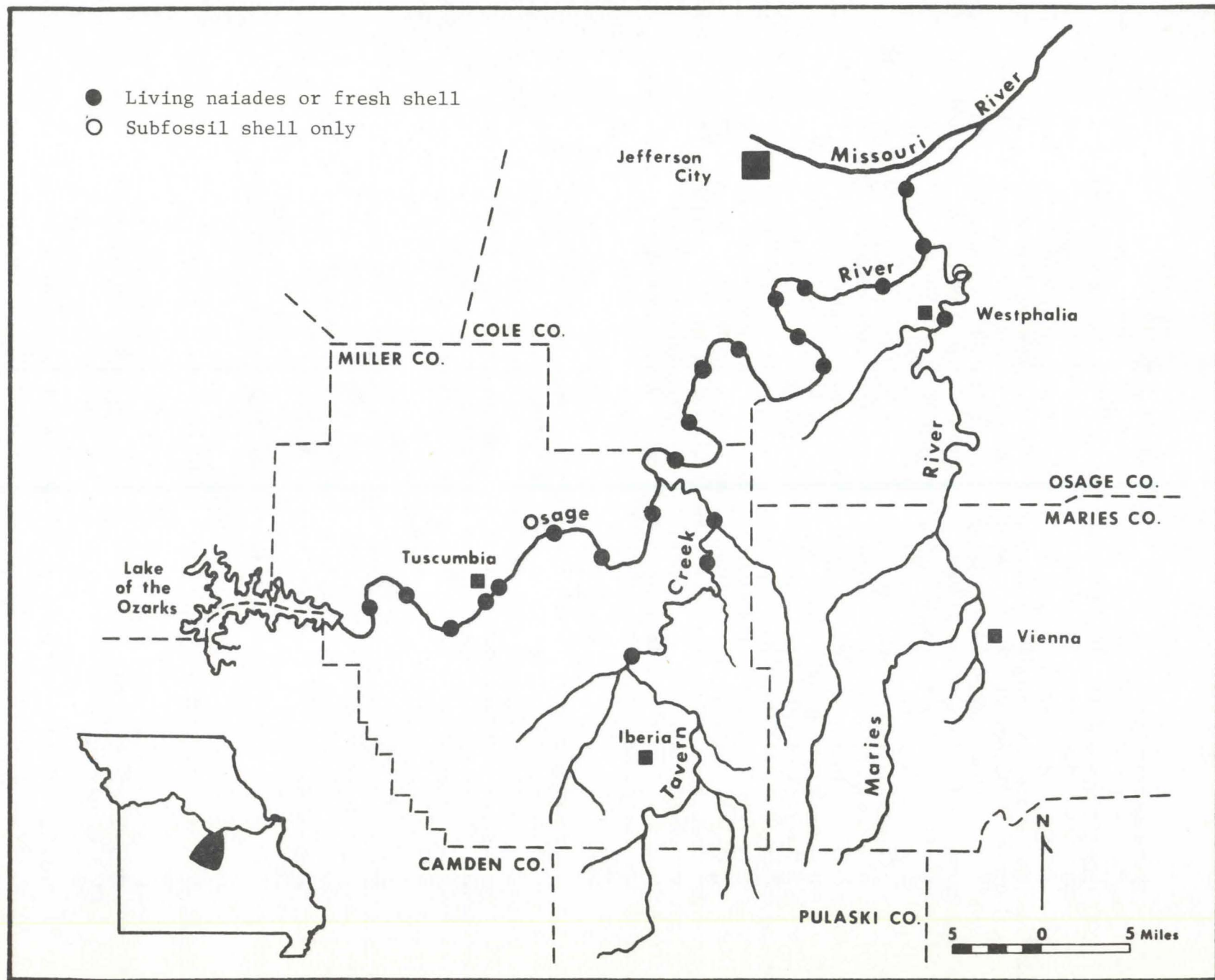


Figure 41. Distribution of *Ligumia recta* (Lamarck in 1819) in the lower Osage River, Tavern Creek, and Maries River.

Ligumia subrostrata (Say 1831)

Pond Mussel

Status: Unclassified.

Physical Description (Parmalee 1967): The shells are fairly solid, elongated, somewhat elliptical and moderately inflated. Posterior ridge is prominent and rounded. Shells sometimes appear slightly alate dorsally behind the beaks. Beaks are full and slightly elevated above the hinge line; beak sculpture consists of six to ten distinct, delicate ridges drawn up in the middle. Epidermis is a dull, brownish-yellow to black and there are usually faint dark green rays on the posterior half of the shell. Cardinal teeth are compressed, thin, moderately elevated and divergent in the left valve. Lateral teeth are long, thin and straight. Beak cavities are fairly shallow. Nacre is white. Adults commonly 1 to 4 inches long.

Geographic Distribution: L. subrostrata was found at only one site in Tavern Creek and at four sites in Maries River; none were found in the lower Osage River (Fig. 42). This species was uncommon in the lower Osage River Basin. Utterback (1915; 1917) found this species in Flat, Hinkson and Lost creeks, and in the Grand, Blackwater and Neosho river basins. Oesch (in press) reported a somewhat widespread but spotty distribution of L. subrostrata in Missouri. L. subrostrata is known from the entire Mississippi River Basin, north as far as Wisconsin and South Dakota and south as far as Arkansas (Parmalee 1967; Johnson 1980).

Habitat: In the lower Osage River Basin, L. subrostrata occurred in a silt and sand to gravel and cobble substrate in 1 inch to 3.5 feet of water in slow (less than 0.2 ft./sec. at the bottom) current. Buchanan (1979; 1980) reported this species from a silt, silt, gravel and cobble, or cobble substrate in 2 inches to 3.5 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (1.9 ft./sec. at the bottom) water in the Meramec and Little Black river basins. It was most common in slow to no current, and was a headwater species in the Meramec River Basin.

Relative Abundance: L. subrostrata comprised less than 0.1% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 0.2% and 0.4%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is widespread and locally common in Missouri (Oesch in press), Illinois (Parmalee 1967), eastern Kansas (Murray and Leonard 1962), and western Indiana (Goodrich and van der Schalie 1944).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Green sunfish, Lepomis cyanellus; orangespotted sunfish, Lepomis humilis; bluegill, Lepomis macrochirus; largemouth bass, Micropterus salmoides (Fuller 1978).

Commercial Value: None.

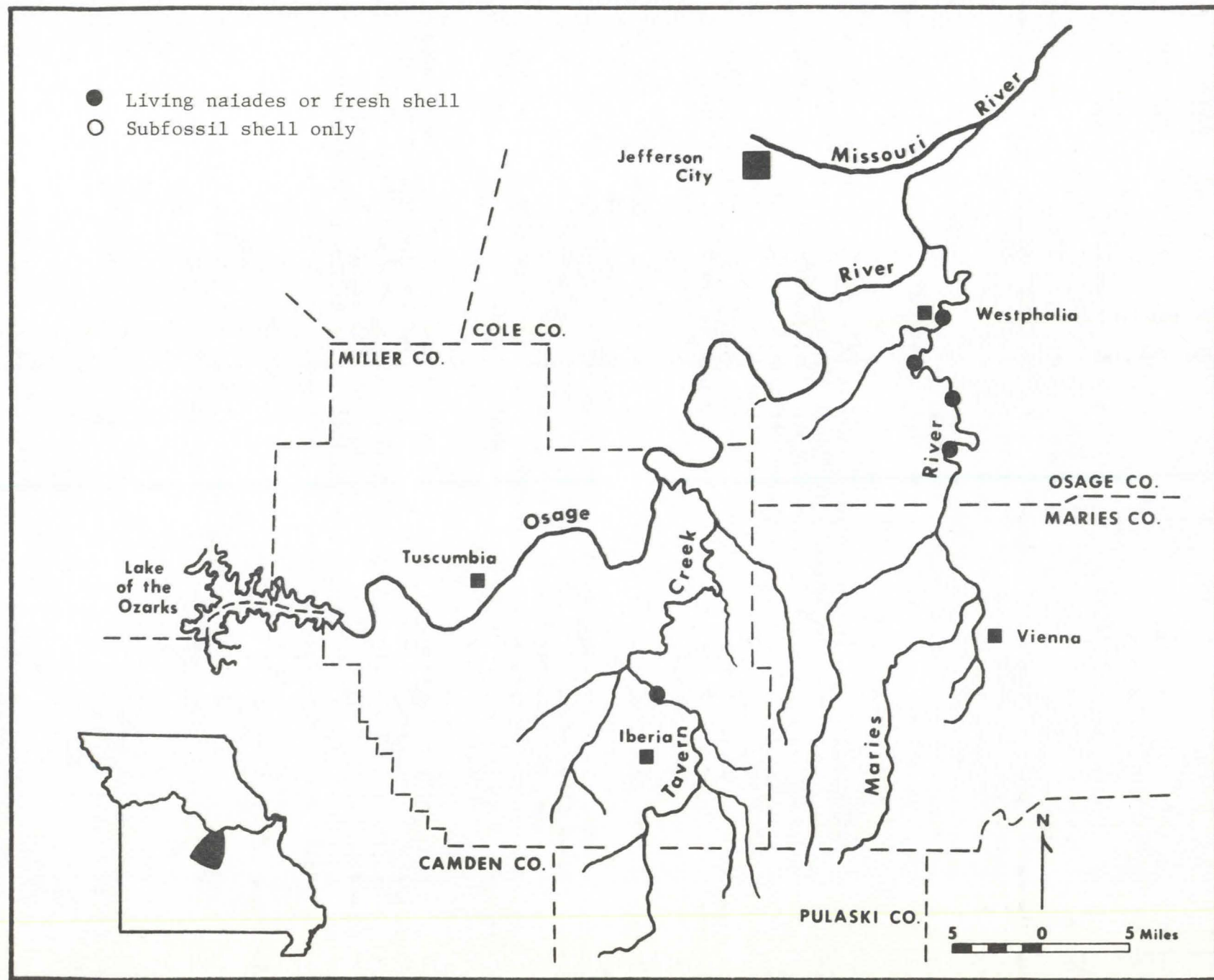


Figure 42. Distribution of *Ligumia subrostrata* (Say 1831) in the lower Osage River, Tavern Creek, and Maries River.

Lampsilis teres teres (Rafinesque 1820)

Slough Sand-Shell

Status: Unclassified.

Physical Description (Baker 1928; Parmalee 1967): The shells are elongated, inflated, and not very thick. Anterior end is rounded and the posterior end pointed. Posterior ridge is rounded. Beaks are depressed; beak sculpture consists of eight to 10 distinct ridges looped and drawn up in middle. Epidermis is smooth, shiny and greenish-yellow, with many dark green rays. Cardinal teeth are elevated, compressed, elongated and serrated. Lateral teeth are long, nearly straight and finely striated. Beak cavities are shallow. Nacre is white. Adults commonly 2 to 5 inches long.

Geographic Distribution: L. t. teres occurred throughout the lower Osage River Basin except for the upper reaches of Maries River (Fig. 43). This species was common in Maries River and Tavern Creek. Early in this century, Utterback (1915; 1917) found this species in lower Lake Contrary, northwest Missouri lakes, the Chariton, Mississippi, Osage and Grand rivers and in the Meramec and Blackwater river basins. Based on recent records (Duchrow 1974; Branson 1967; Oesch in press), L. t. teres occurs throughout Missouri. In North America, L. t. teres has been reported from the Upper Mississippi River Basin, south to Tennessee and Arkansas (Parmalee 1967).

Habitat: L. t. teres was found in an array of substrates from silt to cobble and boulder, in 2 inches to 10 feet of water in standing (0.0 ft./sec. at the bottom) to slowly moving (0.7 ft./sec. at the bottom) water. Buchanan (1980) reported it from a similar range of substrates, in 2 inches to 3.5 feet of water in standing to moderately-flowing (1.5 ft./sec. at the bottom) current in the Meramec River Basin. Other authors (Baker 1928; Murray and Leonard 1962; Parmalee 1967) found this species on a mud or rocky bottom in slow to moderate current in small, medium-sized and large rivers.

Relative Abundance: L. t. teres comprised 0.5% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 0.8% of the living naiades found in the Meramec River Basin (Buchanan 1980). L. t. teres is common in Missouri (Oesch in press) and southeastern Kansas (Murray and Leonard 1962), widespread and locally abundant in Illinois (Parmalee 1967), and uncommon in Indiana (Goodrich and van der Schalie 1944).

Breeding Season: Bradytictic (Baker 1928).

Fish Host: White crappie, Pomoxis annularis; black crappie, Pomoxis nigromaculatus (Utterback 1915).

Commercial Value: Used as a source of inlay material for pearl-handled knives and similar objects (Stansbery 1973).

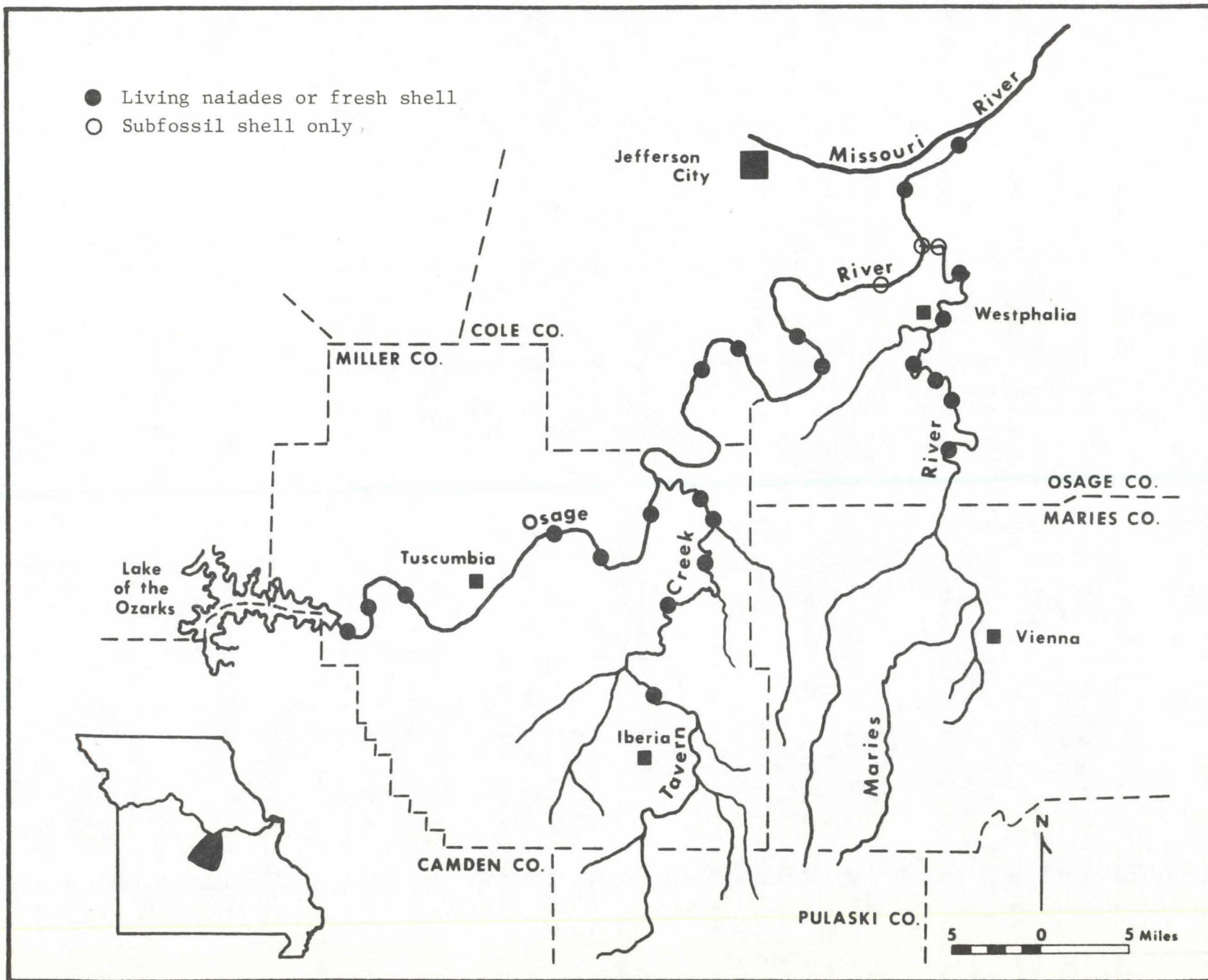


Figure 43. Distribution of Lampsilis teres teres (Rafinesque 1820) in the lower Osage River, Tavern Creek, and Maries River.

Lampsilis radiata luteola (Lamarck 1819)

Fat Mucket

Status: Unclassified.

Physical Description (Parmalee 1967; Utterback 1915; Baker 1928): The shells are elliptical, rounded anteriorly and bluntly pointed posteriorly. Females are expanded and truncated posteriorly. Beaks are large and low; beak sculpture consists of six to 10 fine, double-looped bars. Epidermis is yellowish to brownish, smooth, shiny and usually with numerous green rays. Cardinal teeth are erect, divergent, roughened and thin to triangular. Lateral teeth are erect, straight, and thin to heavy. Beak cavities are shallow. Nacre is bluish-white. Adults commonly 2 to 5 inches long.

Geographic Distribution: L. r. luteola was found throughout most of the lower Osage River Basin (Fig. 44). It was common and locally abundant in Maries River and Tavern Creek. Utterback (1915; 1917) reported this species from the Mississippi, White and Black rivers and the Osage, Blackwater, Meramec, Gasconade, Neosho, and St. Francis river basins. He did not find it in north Missouri. Oesch (in press) reported a nearly statewide distribution for this species. In North America, L. r. luteola has been reported from the entire Mississippi River Basin and all of Canada east of the Rocky Mountains (Burch 1973).

Habitat: L. r. luteola occurred in a range of substrates from silt to gravel, cobble and boulder in 1 inch to 18 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.6 ft./sec. at the bottom) water. Buchanan (1979; 1980) reported this species from similar habitats in the Meramec and Little Black river basins. Ortmann (1919) stated that this species prefers quiet water and sandy-muddy bottoms. Baker (1928) found L. r. luteola in quiet and swift water in small streams and large rivers on a mud bottom.

Relative Abundance: L. r. luteola comprised 4.8% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 11.6% and 2.9%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is common and locally abundant in Missouri (Oesch in press), Illinois (Parmalee 1967), southeastern Kansas (Murray and Leonard 1962), Indiana (Goodrich and van der Schalie 1944), and Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Bluegill, Lepomis macrochirus; yellow perch, Perca flavescens; walleye, Stizostedion vitreum; smallmouth bass, Micropterus dolomieu; largemouth bass, Micropterus salmoides; white crappie, Pomoxis annularis; and eight other fish species (Fuller 1978).

Commercial Value: Used for making buttons (Stansbery 1973).

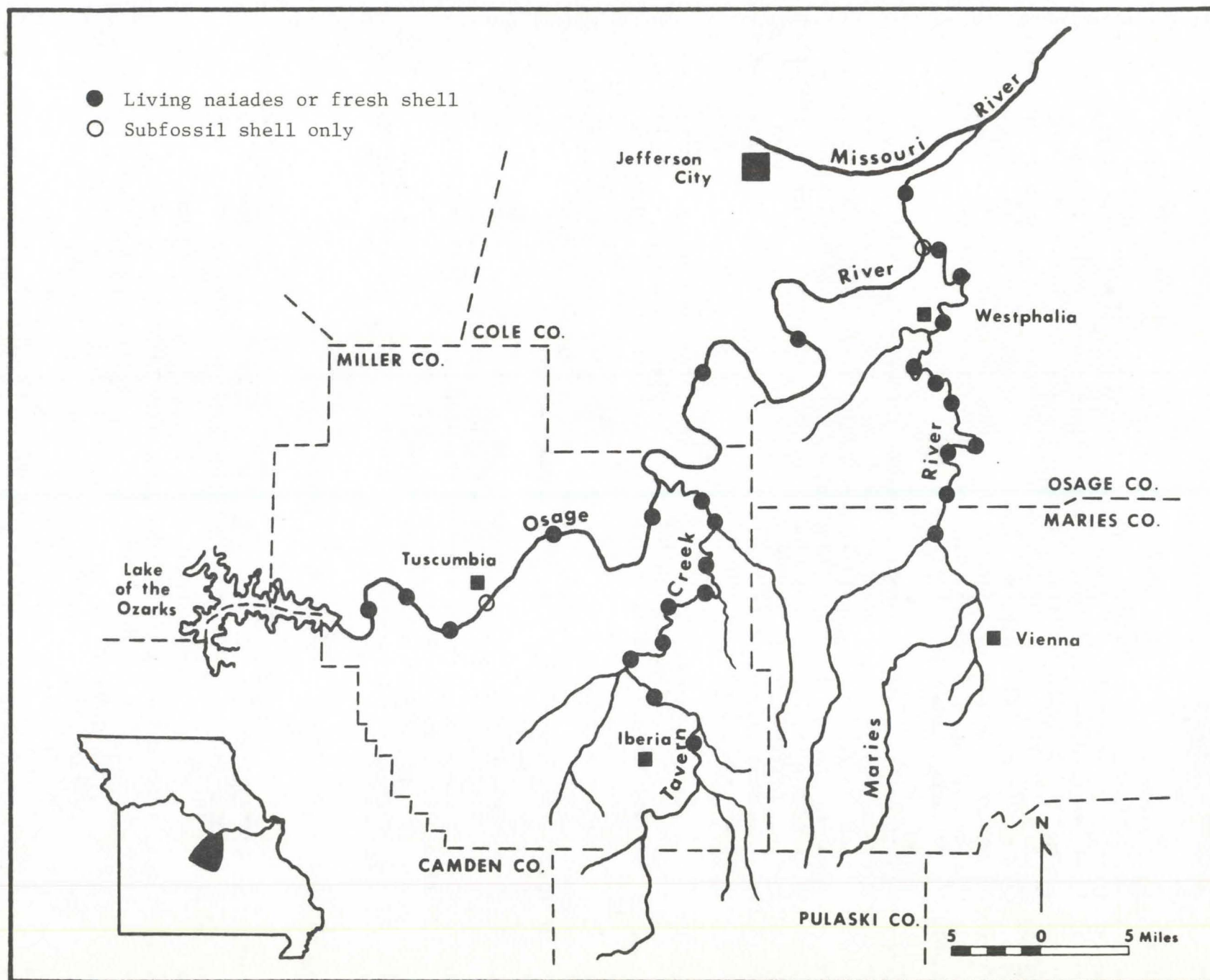


Figure 44. Distribution of *Lampsilis radiata luteola* (Lamarck 1819) in the lower Osage River, Tavern Creek, and Maries River.

Lampsilis ventricosa (Barnes 1823)

Pocketbook

Status: Unclassified.

Physical Description (Baker 1928; Parmalee 1967): The shells are large, subovate to subelliptical, thin to thick, inflated and swollen and high in old females. Anterior end is rounded and the posterior end is bluntly pointed. Shells anterior to beaks are somewhat alate. Beaks are swollen and elevated; beak sculpture consists of four or five coarse bars; the second and third tend to be double-looped. Epidermis is smooth, shiny, yellowish-green and has numerous dark green bands. Cardinal teeth are heavy, compressed to stumpy and serrated. Lateral teeth are high, straight and lamellar. Beak cavities are broad and deep. Nacre is white. Adults commonly 2 to 6 inches long.

Geographic Distribution: L. ventricosa occurred throughout the lower Osage River Basin except for the upper reaches of Maries River (Fig. 45). This species was found at 38 of the 43 sites sampled. Both Utterback (1915; 1917) and Oesch (in press) reported L. ventricosa from all parts of Missouri. In North America, L. ventricosa has been reported from the entire Mississippi River Basin, the St. Lawrence River system and the Hudson Bay drainages (Burch 1973).

Habitat: L. ventricosa was found in an array of substrates from silt to rubble and boulder, in 1 inch to 20 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.6 ft./sec. at the bottom) water. Buchanan (1979; 1980) found this species in a similar range of habitats in the Meramec and Little Black river basins. Other authors (Murray and Leonard 1962; Goodrich and van der Schalie 1944; Parmalee 1967; Baker 1928) found L. ventricosa on a sand or gravel substrate in slow to swift current in small to large rivers.

Relative Abundance: L. ventricosa comprised 3.2% of the living naiades found in the lower Osage River Basin (Table 3). This species comprised 6.3% and 2.8%, respectively, of the living naiades found in the Meramec and Little Black river basins (Buchanan 1979; 1980). It is a widespread and common species in Missouri (Oesch in press), Illinois (Parmalee 1967), southeastern Kansas (Murray and Leonard 1962), Indiana (Goodrich and van der Schlie 1944), Minnesota (Dawley 1947), and Wisconsin (Mathiak 1979).

Breeding Season: Bradytictic (Baker 1928).

Fish Host: White crappie, Pomoxis annularis; sauger, Stizostedion canadense; possibly bass, Micropterus spp.; bluegill, Lepomis macrochirus and yellow perch, Perca flavescens (Baker 1928).

Commercial Value: A popular button shell and used in the manufacture of plastic objects containing crushed polished shell (Stansbery 1973).

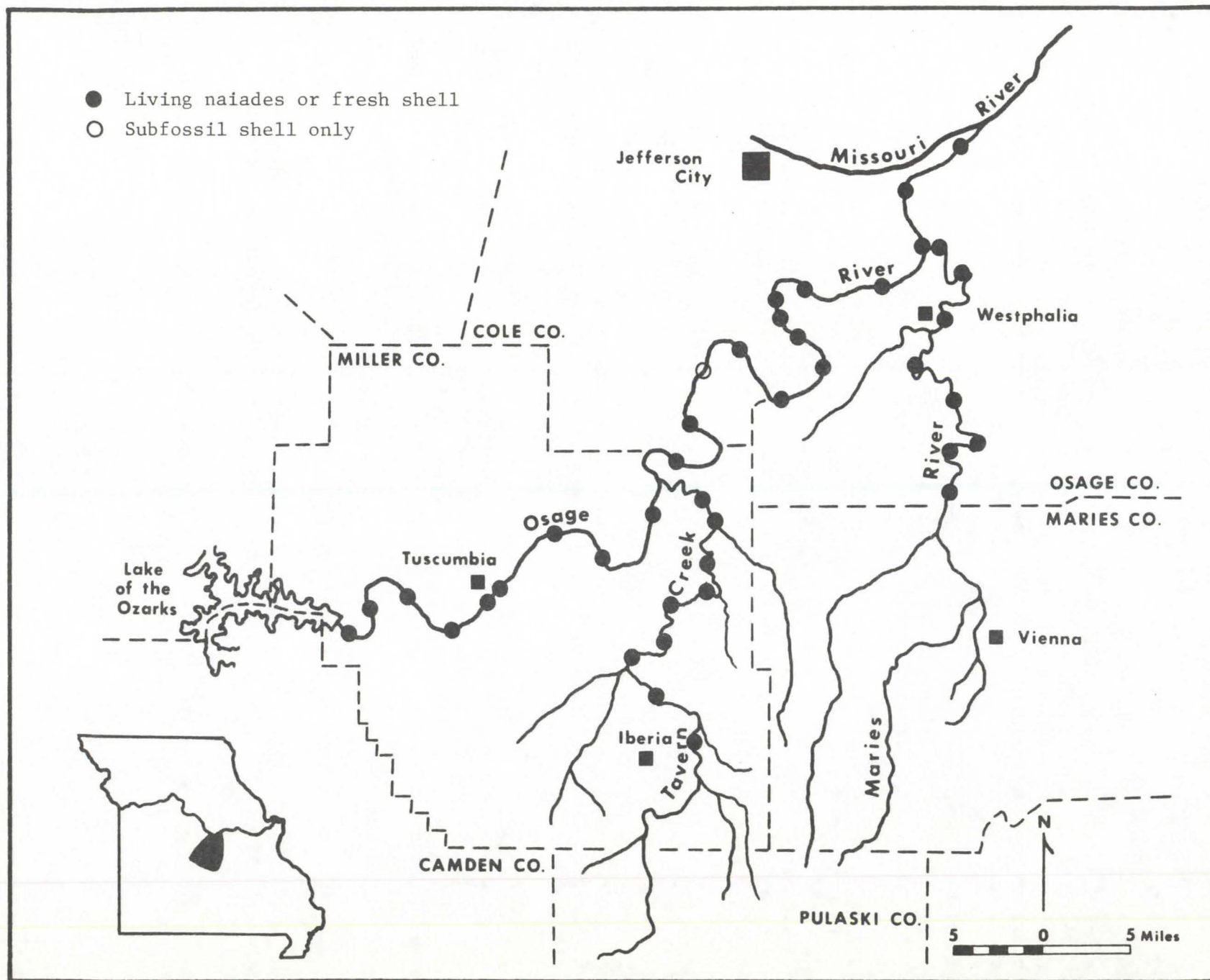


Figure 45. Distribution of Lampsilis ventricosa (Barnes 1823) in the lower Osage River, Tavern Creek, and Maries River.

Lampsilis reeviana brittsi (Simpson 1900)

Britt's Shell

Status: Unclassified.*

Physical Description (Utterback 1915): The shells are elliptical and thin. Anterior end is evenly rounded and the posterior ridge is absent. Beaks are large but low, with inverted V-shaped ridges. Epidermis is smooth, shiny and straw-colored and has coarse broken rays posteriorly. Cardinal teeth are erect. Lateral teeth are blade-like. Nacre is bluish or white. Beak cavities wide and moderately deep. Adults commonly 1 to 3 inches long.

Geographic Distribution: In the lower Osage River Basin, L. r. brittsi occurred only in Tavern Creek and Maries River (Fig. 46). It was found at only 5 of the 43 sites sampled. None were found in the lower Osage River. Utterback (1917) reported this species only from the Ozark Plateau in Missouri. More recently, L. r. brittsi is known from the Sac, Niangua and Big Piney rivers (Oesch in press), and the Meramec River Basin (Buchanan 1980).

Habitat: L. r. brittsi was found in a silt, sand and gravel to a sand, silt, gravel, cobble and boulder substrate in 1 inch to 3.5 feet of water in standing (0.0 ft./sec. at the bottom) to moderately-flowing (1.4 ft./sec. at the bottom) water. In the Meramec River Basin this species occurred in a variety of substrates from silt to bedrock, in 1 inch to 3.5 feet of water in standing to moderately-flowing (1.5 ft./sec. at the bottom) water (Buchanan 1980).

Relative Abundance: L. r. brittsi comprised only 0.1% of the living naiades found in the lower Osage River Basin (Table 3). This species was more abundant in the Meramec River Basin, where it comprised 5.9% of the living naiades found and was typically a headwater species (Buchanan 1980). It is common and locally abundant in Missouri on the north slope of the Ozarks (Oesch in press).

Breeding Season: Bradytictic (Utterback 1915).

Fish Host: Unknown.

Commercial Value: None.

* Note: Lampsilis reeviana brittsi is one of three subspecies of Lampsilis brevicula found in Missouri (personal communication with Dr. David H. Stansbery, Museum of Zoology, Ohio State University). Lampsilis brevicula is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (United States Department of the Interior, Fish and Wildlife Service 1980).

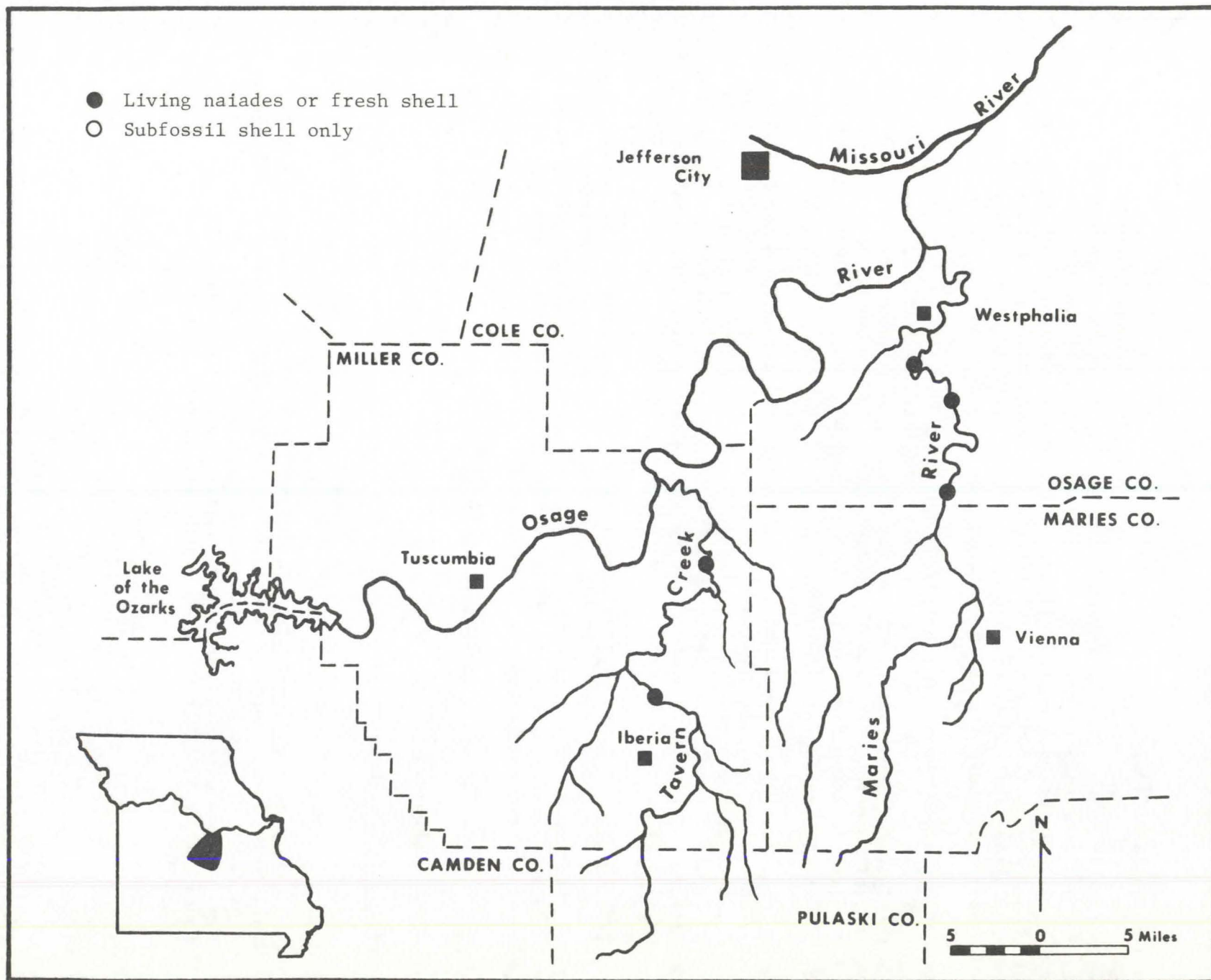


Figure 46. Distribution of *Lampsilis reeviana brittsi* (Simpson 1900) in the lower Osage River, Tavern Creek, and Maries River.

Corbicula leana (Prime 1864)

Asiatic Clam

Status: Unclassified.

Physical Description (Parmalee 1967): The shells are small, solid and ovate when young, and triangular when mature. Beaks are high, turned inward, central and elevated above the hinge line. Epidermis is cream-colored to black. Three cardinal teeth are present in each valve. Two lateral teeth are present on each side of the cardinal teeth in the right valve and one is present on each side of the cardinal teeth in the left valve. Beak cavities are deep. The nacre is white to light purple. Adults commonly 0.5 to 1.5 inches long.

Geographic Distribution: C. leana was found throughout the lower Osage River and the downstream portions of Maries River and Tavern Creek (Fig. 47). It was not found in headwaters. C. leana was first encountered in Missouri in 1964 (Oesch 1974). It is known from all of the larger Missouri streams south of the Missouri River and is probably present in most of the larger Missouri streams north of the Missouri River. In North America, C. leana is known from the Atlantic Ocean to the Pacific Ocean, and from the Gulf of Mexico to Wisconsin and Minnesota (Parmalee 1967; Britton and Morton 1979).

Habitat: C. leana was found in an array of substrates from silt to sand, gravel, cobble and boulder, in 1 inch to 15 feet of water in standing (0.0 ft./sec. at the bottom) to swiftly-flowing (2.0 ft./sec. at the bottom) water. Parmalee (1967) stated that C. leana is found on a sand and mud bottom, usually in quiet water 2 feet to 4 feet deep.

Relative Abundance: C. leana was extremely abundant in the lower Osage River, as it is in many streams in Missouri (Oesch in press) and other parts of North America.

Breeding Season: Whenever the water temperature exceeds 19°C (Britton and Morton 1979).

Fish Host: Development direct; no parasitic larval stage.

Remarks: This species is found in great concentrations, and has been known to plug the water intakes of power facilities and other industries (Oesch 1974). Introduced into the United States in 1938 (Oesch 1974).

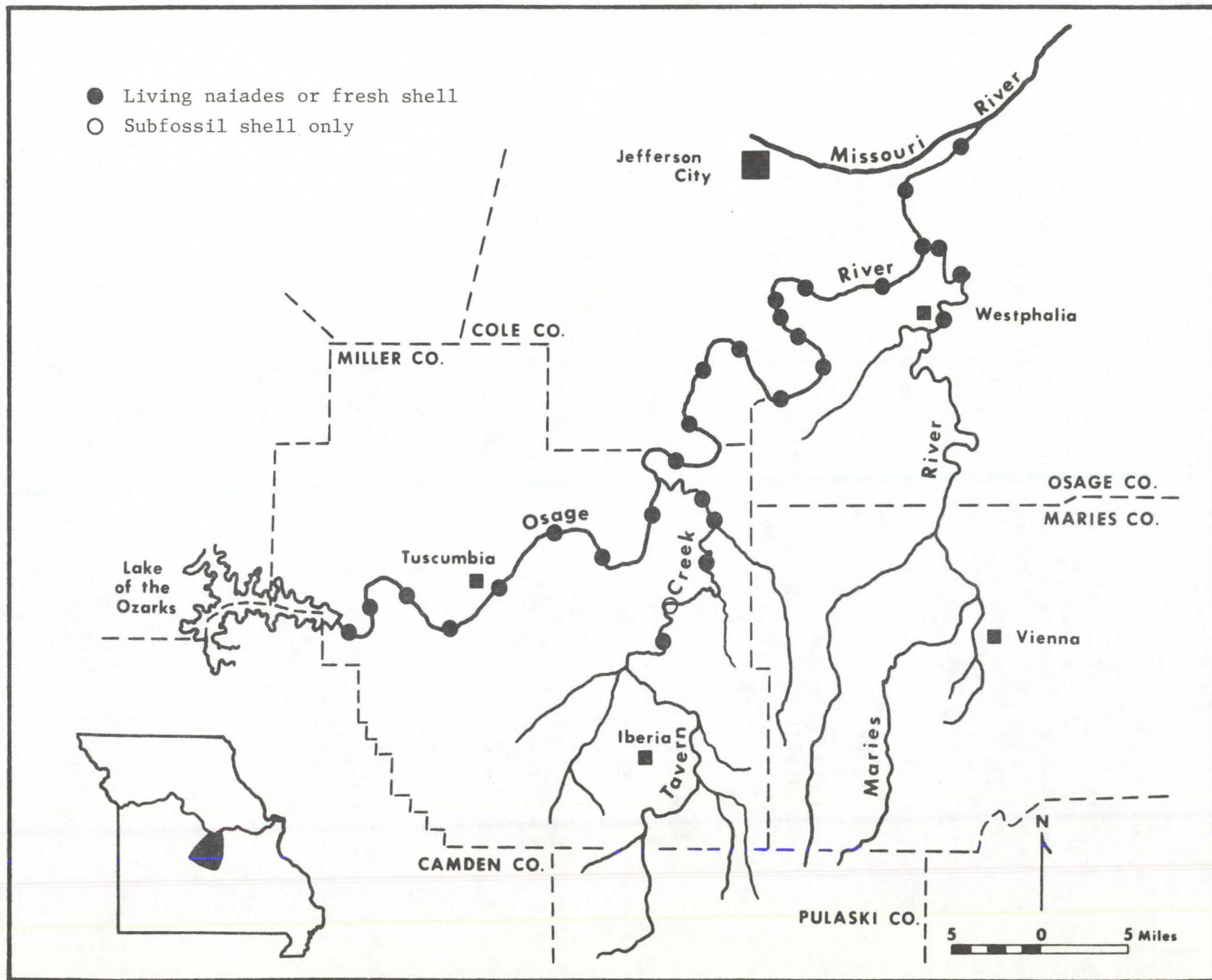


Figure 47. Distribution of Corbicula leana (Prime 1864) in the lower Osage River, Tavern Creek, and Maries River.

SUMMARY AND RECOMMENDATIONS

The lower Osage River, Tavern Creek, and Maries River provide generally favorable habitat for naiades throughout most of their lengths. A total of 36 species were found in these streams; 34 in the lower Osage River, 24 in Tavern Creek, and 26 in the Maries River. Three species, Anodonta grandis corpulenta, Arcidens confragosus, and Obovaria olivaria, all found in the lower Osage River, had not been reported previously from the lower Osage River Basin. A. g. corpulenta had not been reported previously from the Osage River Basin. Fusconaia ebena, previously collected in the lower Osage River in low numbers, was not found. Lampsilis orbiculata, listed as endangered on the United States List of Endangered and Threatened Wildlife and Plants, Cumberlandia monodonta, under Notice of Review for possible addition to the above list, and four Missouri rare or endangered species, A. g. corpulenta, A. confragosus, Elliptio crassidens crassidens, and O. olivaria, were found in the lower Osage River. No federal or Missouri endangered species were found in Tavern Creek or the Maries River.

A total of 21,593 living naiades were examined at 43 sites; 18,038 at 23 sites in the lower Osage River, 1,284 at 9 sites in Tavern Creek, and 2,271 at 11 sites in the Maries River. Ten species comprised 92.0% of the living naiades found in the lower Osage River Basin: Megaloniais nervosa (51.5%), Amblema plicata plicata (9.1%), Quadrula pustulosa (8.1%), Cyclonaias tuberculata (4.9%), Lampsilis radiata luteola (4.8%), Lampsilis ventricosa (3.2%), Pleurobema coccineum (2.8%), Fusconaia flava (2.7%), Elliptio dilatata (2.6%), and Potamilus alatus (2.3%). M. nervosa, Q. pustulosa, C. tuberculata, and A. p. plicata were the most abundant species in the lower Osage River; L. r. luteola, P. alatus, A. p. plicata, and L. ventricosa were the most abundant species in Tavern Creek; and A. p. plicata, L. r. luteola, and L. ventricosa were the most abundant species in the Maries River. L. orbiculata and C. monodonta were uncommon in the lower Osage River Basin, and comprised only 0.1% (17 specimens) and 0.2% (46 specimens), respectively, of all living naiades found in the lower Osage River Basin. Known populations of L. orbiculata and C. monodonta should be sampled periodically to determine trends in distribution and abundance.

Releases of water from the hypolimnion of Lake of the Ozarks appear to inhibit establishment of naiad populations in the main channel in the 16 miles of the Osage River immediately below Bagnell Dam.

No living naiades were found in areas dredged by the three large, commercial gravel dredging operations, Ozark Sand Company, Inc. (river mile 78.0 to 81.25 left bank), Osage Sand and Gravel (river mile 65.0 to 68.0 left bank), and Roweth Sand and Gravel Company, Inc. (river mile 22.0 left bank), on the lower Osage River. Few living naiades were found in the undredged river bottom adjacent to each operation. The re-establishment of naiades in dredged areas appears to take many years.

Concentrations of naiades containing L. orbiculata were found downstream from Osage Sand and Gravel and Roweth Sand and Gravel Co. L. orbiculata was also found near five smaller dredging sites on the lower Osage River, two active sites (river mile 46.0 left bank and 17.5 left bank), two inactive sites (river mile 23.9 left bank and from river mile 5.0 to 10.0 main channel), and one site proposed for dredging (river mile 12.1 to 12.7 right bank). Instream gravel dredging should not be permitted immediately downstream from Osage Sand and Gravel, below Roweth Sand and Gravel Co., or at the five smaller dredging sites on the lower Osage River. Floodplain dredging at all

dredging sites is unlikely to adversely affect L. orbiculata and C. monodonta provided the river configuration is not altered. Instream gravel dredging should not be permitted at any new site on the lower Osage River, particularly the lower 66 miles, without first conducting a survey of naiades at the site to determine the presence or absence of L. orbiculata and C. monodonta.

Removal and processing of sand and gravel at Ozark Sand Co., Osage Sand and Gravel, and Roweth Sand and Gravel Co. increases turbidity downstream during dredging and washing and increases the depth of the Osage River at the dredging site for an indefinite period of time. The turbidity of the Osage River was increased significantly 3,700 ft. below Ozark Sand Co., 1,350 ft. below Osage Sand and Gravel, and 250 ft. below Roweth Sand and Gravel Co. during dredging operations. Turbidity was significantly higher along the left shore than along the right shore (all three dredging operations are located on the left descending bank) at Ozark Sand Co. and Roweth Sand and Gravel Co. Turbidity was also significantly higher at the bottom than at the surface at all three operations. Dredging has increased the depth (up to 60 ft.) of the Osage River at each site.

Continued gravel dredging in areas previously dredged at all three commercial dredging operations is unlikely to have a serious adverse impact on L. orbiculata and C. monodonta if the river configuration is not altered and dredging is not expanded downstream at Osage Sand and Gravel and Roweth Sand and Gravel Co. The impact of turbidity on concentrations of naiades below Osage Sand and Gravel and Roweth Sand and Gravel Co. is unknown. Additional research is needed on the effects of gravel dredging on naiades.

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GLOSSARY

Adductor muscle - the muscle that closes the two valves of the shell; the muscle fibers extend from one valve to the opposing valve.

Adductor scar - point of attachment of the adductor muscle to the interior of the shell.

Alate - said of shells that have an anterior or posterior wing-like projection of the two valves of the shell, extending dorsally above the hinge line.

Beak (Umbo) - the raised part of the dorsal margin of each of the shell valves.

Beak cavity - the cavity which extends into the beak on the inside of each valve.

Bradytictic - long-term breeders; i.e. naiades that retain developing glochidial larvae in their gills through the year, except in the Nearctic summer.

Cardinal teeth - teeth on the anterior portion of the interior portion of the shell, ventral to the hinge line.

Endangered (Nationally) - those species in danger of extinction throughout all or a significant portion of their ranges (U.S. Dept. Interior, Fish and Wildlife Service 1976).

Endangered (In Missouri) - a species or subspecies whose prospects for survival within the state are in immediate jeopardy. An endangered species must have help or extirpation will probably follow (Missouri Department of Conservation 1977).

Epidermis - the most external layer of the shell.

Gill - the platelike or filamentous outgrowth, within the mantle cavity, serving as the respiratory organ of the naiad.

Growth lines - lines (often indistinct) of growth on the epidermis of the shell.

Hinge line - the dorsal area of the shell that forms the pivot upon which the two valves rotate as they open and close.

Lateral teeth - elongate, raised, interlocking structures on the hinge line of the valve, posterior to the beak.

Ligament - an elastic band of tissue which connects the two valves of the naiad shell at the hinge.

Marsupium - a brood-pouch for eggs and larvae, formed by one or more gills.

Muscle scars - points at which the muscles are attached to the shell. Usually evident as indentations in the shell ventral to the hinge line and anterior or posterior to the beak.

Nacre - the white or iridescent inner layer of shell, often characteristically colored.

Posterior ridge - a ridge on the external surface of the shell extending from the beak to the ventral posterior margin.

Pustules - blister-like raised structures on the external surface of the shell.

Rare (In Missouri) - a species or subspecies that, although not presently threatened with extirpation, is in such small numbers within the state that it could easily become endangered if its environment worsens (Missouri Department of Conservation 1977).

Ray - a streak or line, continuous or broken, on the external surface of the shell.

Rhomboidal - rhomboid in shape, i.e. quadrilateral with opposite sides and angles equal, but neither equilateral nor equiangular.

Sulcus - a groove, furrow or channel.

Tachytictic - short-term breeders; naiades which carry glochidial larvae in their gills only during the Nearctic summer.

Threatened - those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range (U.S. Dept. Interior, Fish and Wildlife Service 1976).

Truncated - the posterior margin of the shell is more or less at a right angle to the ventral and dorsal margins.

Tubercle - a small, rounded, raised structure on the external surface of a naiad shell.

Umbo - see Beak.

Valve - the right or left half of a naiad shell.

Voucher - a specimen of a naiad species retained as evidence of the occurrence of that species at that particular location in a stream or lake.

APPENDICES

Appendix A. Collecting sites on the lower Osage River, Tavern Creek, and Maries River.

Lower Osage River

- 0-1. Osage R. at and below Ozark Sand Co. (Hwy. 54), 2.4 mi. S of Bagnell, and 8.5 mi. WSW of Tuscumbia; T40N, R15W, S28 & 29; Miller Co.; River Mile 80.8; June 2 and 3 and Sept. 6, 1980.
- 0-2. Osage R. above head and along right side of Brockmans Island, 1.0 mi. SSE of Bagnell, and 7.25 mi. WSW of Tuscumbia; T40N, R15W, S16 & 21; Miller Co.; River Mile 77.6; May 12, June 4 and 5, 1980.
- 0-3. Osage R. along upper left side and lower end of Cotton Island, 2.6 mi. E of Bagnell, and 5.1 mi. W of Tuscumbia; T40N, R15W, S11 & 14; Miller Co.; River Mile 74.0; June 5 and 6, 1980.
- 0-4. Osage R. at head and lower end of unnamed island, 4.4 mi. NNW of Ulman, and 2.75 mi. SW of Tuscumbia; T40N, R14W, S20 & 29; Miller Co.; River Mile 69.0; June 11 and 12, 1980.
- 0-5. Osage R. at and below Osage Sand and Gravel Co. (Tuscumbia), 5.6 mi. NNW of Ulman, and 7.5 mi. WSW of Capps; T40N, R14W, S10 & 11; Miller Co.; River Mile 66.0; Sept. 7, 10, and 23, 1980.
- 0-6. Osage R. approx. 0.5 mi. downstream from Hwy. 17, 1.1 mi. NE of Tuscumbia, and 6.6 mi. SW of Mary's Home; T40N, R14W, S2 & 11; Miller Co.; River Mile 65.0; June 12 and 13, 1980.
- 0-7. Osage R. at Kings Bluff Access (MDC), 2.6 mi. SSW of Mary's Home, and 5.2 mi. NE of Tuscumbia; T41N, R13W, S29; Miller Co.; River Mile 60.5; June 16 and 17, 1980.
- 0-8. Osage R. along left side and above Berry Island, 1.7 mi. NW of Capps, and 6.4 mi. ENE of Tuscumbia; T40N, R13W, S3 and T41N, R13W, S34; Miller Co.; River Mile 57.4; June 17 and 18, 1980.
- 0-9. Osage R. at lower end of unnamed island, 2.8 mi. NW of St. Elizabeth, and 3.4 mi. ESE of Mary's Home; T41N, R12W, S19, NW $\frac{1}{4}$; Miller Co.; River Mile 52.1; July 14 and 15, 1980.
- 0-10. Osage R. at lower end and at dike along right side of Lynn Island, 5.1 mi. N of St. Elizabeth, and 5.3 mi. ENE of Mary's Home; T41N, R12W, S4 & 5; Miller Co.; River Mile 46.1; July 16 and 17, 1980.
- 0-11. Osage R. at lower left side of unnamed island, 2.3 mi. WSW of St. Thomas, and 3.8 mi. ENE of Henley; T42N, R12W, S28; Cole Co.; River Mile 40.5; July 18 and Aug. 4, 1980.
- 0-12. Osage R. at lower end of unnamed island, 2.8 mi. NNW of St. Thomas, and 2.8 mi. SSW of Osage Bluff; T42N, R12W, S10, NW $\frac{1}{4}$; Cole Co.; River Mile 37.0; Aug. 5, 1980.

Appendix A. (Continued)

- 0-13. Osage R. Approx. 0.5 mi. downstream from Hwy. "B", 3.5 mi. NNE of St. Thomas, and 5.1 mi. SSW of Wardsville; T42N, R12W, S1; Cole Co.; River Mile 33.5; Aug. 6 and 7, 1980.
- 0-14. Osage R. 2.3 mi. SW of Osage Bend, and 2.9 mi. ENE of St. Thomas; T42N, R11W, S20; Cole Co.; River Mile 29.7; Aug. 7, 1980.
- 0-15. Osage R. below unnamed island, 2.6 mi. SSW of Folk, and 7.6 mi. SW of Westphalia; T42N, R11W, S15; Osage Co.; River Mile 26.9; Aug. 8 and 19, 1980.
- 0-16. Osage R. along left side and below unnamed island, 5.7 mi. SSE of Wardsville, and 6.25 mi. NE of St. Thomas; T42N, R11W, S3 and T43N, R11W, S33, 34; Cole Co.; River Mile 23.7; Aug. 20 and 21, 1980.
- 0-17. Osage R. above Roweth Sand and Gravel Co., 3.4 mi. SSE of Wardsville, and 6.1 mi. NNE of St. Thomas; T43N, R11W, S29; Cole Co.; River Mile 22.2; Aug. 22, 1980.
- 0-18. Osage R. at and below Roweth Sand & Gravel Co., 2.7 mi. SSE of Wardsville, and 6.6 mi. NNE of St. Thomas; T43N, R11W, S20 & 29; Cole Co.; River Mile 21.5; Aug. 1, 22-24, 1980.
- 0-19. Osage R. along right side of Bruemmer's Island, 3.2 mi. SE of Wardsville, and 4.5 mi. SW of Taos; T43N, R11W, S15, 16, 21, & 22; Cole Co.; River Mile 17.6; Aug. 23 and 25, 1980.
- 0-20. Osage R. along left side of dike at head of unnamed island, 2.9 mi. SSE of Taos, and 6.7 mi. ESE of Wardsville; T43N, R10W, S17 & 18; Cole Co.; River Mile 13.6; Aug. 26, Sept. 3 and 23, 1980.
- 0-21. Osage R. at Hwy. 63, 3.6 mi. ESE of Taos, and 9.2 mi. E of Wardsville; T43N, R10W, S10; Cole Co.; River Mile 10.3; Sept. 2 and 3, 1980.
- 0-22. Osage R. at Osage City, 3.6 mi. NNE of Taos, and 9.0 mi. NE of Wardsville; T44N, R10W, S16 & 21; Cole Co.; River Mile 5.6; Sept. 5 and 8, 1980.
- 0-23. Osage R. at Bonnots Mill, 4.3 mi. W of Frankenstein, and 4.8 mi. NNW of Loose Creek; T44N, R10W, S12; Osage Co.; River Mile 1.9; Sept. 9, 1980.

Tavern Creek

- T-1. Tavern Cr. at Hwy. 42, 2.0 mi. NE of Iberia, and 24.6 mi. SE of Eldon; T39N, R12W, S17; Miller Co.; River Mile 32.8; May 22, 1980.
- T-2. Tavern Cr. 1.6 mi. SW of Saint Anthony, and 3.6 mi. N of Iberia; T39N, R13W, S1, SE $\frac{1}{4}$; Miller Co.; River Mile 27.8; June 23, 1980.
- T-3. Tavern Cr. 3.1 mi. NW of Saint Anthony, and 8.5 mi. SE of Tuscumbia; T40N, R13W, S25, SW $\frac{1}{4}$; Miller Co.; River Mile 23.7; June 23 and 25, 1980.

Appendix A. (Continued)

- T-4. Tavern Cr. at Hwy. "A", 2.1 mi. N of Saint Anthony, and 20.0 mi. SE of Eldon, T40N, R12, S29 & 30; Miller Co.; River Mile 20.4; May 22, 1980.
- T-5. Tavern Cr. 2.8 mi. SSW of St. Elizabeth, and 4.3 mi. NNW of Saint Anthony; T40N, R12W, S17, NW $\frac{1}{4}$; Miller Co.; River Mile 17.0; June 25 and 26, 1980.
- T-6. Tavern Cr. at Boeckman Bridge Access (MDC), 2.6 mi. SSE of St. Elizabeth, and 5.25 mi. NNE of Saint Anthony; T40N, R12W, S10; Miller Co.; River Mile 14.1; May 23, 1980.
- T-7. Tavern Cr. 1.3 mi. SE of St. Elizabeth, and 4.25 mi. ENE of Capps; T40N, R12W, S3, NW $\frac{1}{4}$; Miller Co.; River Mile 10.4; June 26, 1980.
- T-8. Tavern Cr. at Hwy. 52, 2.4 mi. NE of St. Elizabeth, and 7.2 mi. ESE of Mary's Home; T41N, R12W, S22, SE $\frac{1}{4}$ and 27, NE $\frac{1}{4}$; Miller Co.; River Mile 6.8; May 22, 1980.
- T-9. Tavern Cr. 3.25 mi. NNE of St. Elizabeth, and 6.4 mi. E of Mary's Home; T41N, R12W, S15; Miller Co.; River Mile 5.2; June 26 and 27, 1980.

Maries River

- M-1. Maries R. at Hwy. 42, 2.25 mi. W of Vienna, and 8.75 mi. NNE of Brinktown; T40N, R10W, S25, NW $\frac{1}{4}$; Maries Co.; River Mile 43.0; May 20, 1980.
- M-2. Maries R. at Hwy. "AA", 2.0 mi. SE of Argyle, and 6.5 mi. NW of Vienna; T41N, R10W, S26; Maries Co.; River Mile 35.0; May 21, 1980.
- M-3. Maries R. 3.6 mi. WSW of Freeburg, and 2.1 mi. NE of Argyle; T41N, R10W, S12, SW $\frac{1}{4}$; Osage Co.; River Mile 32.1; July 29, 1980.
- M-4. Maries R. at Hwy. "P", 4.0 mi. WNW of Freeburg, and 3.25 mi. NE of Argyle; T41N, R10W, S2, NE $\frac{1}{4}$ and T42N, R10W, S35, SE $\frac{1}{4}$; Osage Co.; River Mile 29.0; May 20, 1980.
- M-5. Maries R. 2.25 mi. NW of Freeburg, and 4.7 mi. ENE of Koeltztown; T41N, R9W, S5, NW $\frac{1}{4}$ and T42N, R9W, S32, SW $\frac{1}{4}$; Osage Co.; River Mile 26.7; July 3 and 29, 1980.
- M-6. Maries R. 4.8 mi. SSE of Westphalia, and 6.0 mi. WSW of Rich Fountain; T42N, R10W, S24; Osage Co.; River Mile 22.4; July 1, 1980.
- M-7. Maries R. below Hwy. "T", 3.3 mi. SSE of Westphalia, and 6.1 mi. W of Rich Fountain; T42N, R10W, S14, NW $\frac{1}{4}$; Osage Co.; River Mile 20.1; May 21, 1980.
- M-8. Maries R. 3.1 mi. SSW of Westphalia, and 4.3 mi. SE of Folk; T42N, R10W, S9 & 10; Osage Co.; River Mile 16.8; July 2, 1980.

Appendix A. (Continued)

- M-9. Maries R. at Hwy. 63, 0.7 mi. SE of Westphalia, and 6.2 mi. ENE of Folk; T43N, R10W, S35, NE $\frac{1}{4}$; Osage Co.; River Mile 11.8; May 21 and July 29, 1980.
- M-10. Maries R. 2.6 mi. SSW of Loose Creek, and 3.1 mi. NNE of Westphalia; T43N, R10W, S13, NE $\frac{1}{4}$; Osage Co.; River Mile 4.9; May 25 and July 1, 1980.
- M-11. Maries R. at Hwy. 50, 2.25 mi. SW of Loose Creek, and 4.0 mi. NNE of Westphalia; T43N, R10W, S2, SE $\frac{1}{4}$ and 11, NE $\frac{1}{4}$; Osage Co.; River Mile 1.4; June 27, 1980.

Appendix B.

Table 1. Species and numbers of naiades found from Site 0-1 (River Mile 80.8) to Site 0-2 (River Mile 77.6) in the lower Osage River.

Species	Site: 0-1				0-2			
	River Mile: 80.8				77.6			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta								
Anodonta imbecillis								
Anodonta g. grandis	3				9			
Anodonta grandis corpulenta								
Strophitus u. undulatus								
Arcidens confragosus								
Lasmigona complanata	2				4			
Lasmigona costata								
Megaloniaias nervosa	347				229			
Tritogonia verrucosa	1							
Quadrula quadrula	5				1			
Quadrula metanevra			1	1/2	1			
Quadrula pustulosa	43				45			
Amblema p. plicata	28				43			2
Fusconaia flava	1		2	2/2	2		1	
Cycloniaias tuberculata				2/2			1	1
Pleurobema coccineum	5				1			
Elliptio c. crassidens								1/2
Elliptio dilatata	1				6			
Obliquaria reflexa	6				1			
Actinoniaias ligamentina carinata							1	
Venustaconcha e. ellipsiformis								
Plagiola lineolata			2				2	
Obovaria olivaria				1/2				
Truncilla truncata					7			
Truncilla donaciformis								
Leptodea fragilis	3				4		1	
Potamilus alatus	5				11			
Potamilus ohioensis								
Ligumia recta					1			
Lampsilis t. teres			1			2		
Lampsilis radiata luteola					2	2		
Lampsilis ventricosa	2				2			1 1/2
Lampsilis orbiculata				1/2				

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-3 (River Mile 74.0) to Site 0-4 (River Mile 69.0) in the lower Osage River.

Species	Site: 0-3				0-4			
	River Mile: 74.0				69.0			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta								
Anodonta imbecillis								
Anodonta g. grandis					2			
Anodonta grandis corpulenta					2			
Strophitus u. undulatus				2/2				
Arcidens confragosus								
Lasmigona complanata	1				7			
Lasmigona costata								
Megaloniaias nervosa	547				257			
Tritogonia verrucosa	2				1			
Quadrula quadrula	2				2			
Quadrula metanevra			2		17			
Quadrula pustulosa					117			
Amblema p. plicata	7		1		76			
Fusconaia flava	44				4			
Cycloniaias tuberculata	7				2			
Pleurobema coccineum			2		23			
Elliptio c. crassidens	1							
Elliptio dilatata			2		8			
Obliquaria reflexa	2			1	9			
Actinoniaias ligamentina carinata	1							
Venustaconcha e. ellipsiformis			1/2					
Plagiola lineolata	1				21			
Obovaria olivaria								
Truncilla truncata	2							
Truncilla donaciformis								
Leptodea fragilis	1	1			1	1	1	
Potamilus alatus	8				22			
Potamilus ohioensis								
Ligumia recta			1		3			
Lampsilis t. teres	1							
Lampsilis radiata luteola	2				2			
Lampsilis ventricosa	5				5			
Lampsilis orbiculata								

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-5 (River Mile 66.0) to Site 0-6 (River Mile 65.0) in the lower Osage River.

Species	Site: 0-5				0-6			
	River Mile: 66.0				65.0			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta					2	2		
Anodonta imbecillis								
Anodonta g. grandis					1			
Anodonta grandis corpulenta								
Strophitus u. undulatus								
Arcidens confragosus								
Lasmigona complanata	1				3			
Lasmigona costata								
Megaloniaias nervosa	1374				724			
Tritogonia verrucosa	14				8			
Quadrula quadrula	1				1			
Quadrula metanevra	68				40			
Quadrula pustulosa	299				92			
Amblema p. plicata	103				23			
Fusconaia flava	117				42			
Cyclonaias tuberculata	53				32			
Pleurobema coccineum	46				46			
Elliptio c. crassidens								
Elliptio dilatata	55				34			
Obliquaria reflexa	10				1			
Actinonaias ligamentina carinata	9				10			
Venustaconcha e. ellipsiformis								
Plagiola lineolata	23				8			
Obovaria olivaria								
Truncilla truncata	8							
Truncilla donaciformis	2							
Leptodea fragilis	3				1			1
Potamilus alatus	10				24			
Potamilus ohioensis								
Ligumia recta	25				13			
Lampsilis t. teres								
Lampsilis radiata luteola				1				
Lampsilis ventricosa	35				95			
Lampsilis orbiculata	2				1			

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-7 (River Mile 60.5) to Site 0-8 (River Mile 57.4) in the lower Osage River.

Species	Site: 0-7				0-8			
	River Mile: 60.5				57.4			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta	1				1			
Anodonta imbecillis								
Anodonta g. grandis	5	1						
Anodonta grandis corpulenta								
Strophitus u. undulatus			1					
Arcidens confragosus								
Lasmigona complanata			1		1			
Lasmigona costata								
Megaloniaias nervosa	1593				653			
Tritogonia verrucosa	9				11			
Quadrula quadrula	1				1		1	
Quadrula metanevra	9		1		1			
Quadrula pustulosa	130				10			
Amblema p. plicata	40				61			
Fusconaia flava	38				11			
Cycloniaias tuberculata	14				1			
Pleurobema coccineum	17	1			8		1	
Elliptio c. crassidens								
Elliptio dilatata	13				3		1	
Obliquaria reflexa	3				2		1	
Actinoniaias ligamentina carinata	6				5		1	
Venustaconcha e. ellipsiformis								
Plagiola lineolata	8				3			
Obovaria olivaria								
Truncilla truncata							2	
Truncilla donaciformis								
Leptodea fragilis	3				3			
Potamilus alatus	4				8			
Potamilus ohiensis								
Ligumia recta	6				15			
Lampsilis t. teres	5	1			2			
Lampsilis radiata luteola	1							
Lampsilis ventricosa	10				41			
Lampsilis orbiculata					2			

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-9 (River Mile 52.1) to Site 0-10 (River Mile 46.1) in the lower Osage River.

Species	Site: 0-9				0-10			
	River Mile: 52.1				46.1			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta								
Anodonta imbecillis					1			
Anodonta g. grandis	1				6			
Anodonta grandis corpulenta								
Strophitus u. undulatus								
Arcidens confragosus				4				
Lasmigona complanata	2				9			
Lasmigona costata								
Megaloniaias nervosa	1161	1			738			
Tritogonia verrucosa	1	1			1			
Quadrula quadrula	2				3			
Quadrula metanevra	5				8			1/2
Quadrula pustulosa	12				32			
Amblema p. plicata	66				285			
Fusconaia flava	4	3			7	1		
Cycloniaias tuberculata	2				1			1/2
Pleurobema coccineum	4	4		1/2	9			1 2/2
Elliptio c. crassidens								
Elliptio dilatata	2	1			9			
Obliquaria reflexa		2 2/2		1				1/2
Actinoniaias ligamentina carinata		2 1/2						1
Venustaconcha e. ellipsiformis								
Plagiola lineolata		1			2	1		
Obovaria olivaria								
Truncilla truncata					1			
Truncilla donaciformis								
Leptodea fragilis				1	4	2		
Potamilus alatus	4				29			
Potamilus ohioensis								
Ligumia recta	2				2			
Lampsilis t. teres		1		1				
Lampsilis radiata luteola	1							
Lampsilis ventricosa	10				4			
Lampsilis orbiculata	1			1				1/2

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-11 (River Mile 40.5) to Site 0-12 (River Mile 37.0) in the lower Osage River.

Species	Site: 0-11				0-12			
	River Mile: 40.5				37.0			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta	28						3	1
Anodonta imbecillis								
Anodonta g. grandis					5			
Anodonta grandis corpulenta								
Strophitus u. undulatus								
Arcidens confragosus								
Lasmigona complanata				1/2	7			
Lasmigona costata	1							
Megaloniaias nervosa	1295				88			
Tritogonia verrucosa	1							
Quadrula quadrula	3				1			1
Quadrula metanevra	12	3						1/2
Quadrula pustulosa	1	2	1		2			
Amblema p. plicata	3			1	92			
Fusconaia flava	6		1	1			2	
Cyclonaias tuberculata	11			1 1/2			1	
Pleurobema coccineum	9		1	1	2			1/2
Elliptio c. crassidens								
Elliptio dilatata	10				1		1	
Obliquaria reflexa		1		1			1	
Actinonaias ligamentina carinata	1			1			2	
Venustaconcha e. ellipsiformis								
Plagiola lineolata	1			2			1	
Obovaria olivaria				3/2				1/2
Truncilla truncata								1
Truncilla donaciformis								
Leptodea fragilis	1	1			4			1
Potamilus alatus	1				24			
Potamilus ohioensis					2			
Ligumia recta	3						1	
Lampsilis t. teres					4			
Lampsilis radiata luteola					1			
Lampsilis ventricosa	3							1
Lampsilis orbiculata	1			2 1/2				1/2

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-13 (River Mile 33.5) to Site 0-14 (River Mile 29.7) in the lower Osage River.

Species	Site: 0-13				0-14			
	River Mile: 33.5				29.7			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta	5			1				
Anodonta imbecillis								
Anodonta g. grandis								
Anodonta grandis corpulenta								
Strophitus u. undulatus	1							
Arcidens confragosus								
Lasmigona complanata								
Lasmigona costata								
Megaloniaias nervosa	1168				2			
Tritogonia verrucosa	4							
Quadrula quadrula	2							1
Quadrula metanevra	13							
Quadrula pustulosa	93						1	
Amblema p. plicata	3							1
Fusconaia flava	40						2	
Cyclonaias tuberculata	242	1						
Pleurobema coccineum	25		1		1			
Elliptio c. crassidens								
Elliptio dilatata	92							
Obliquaria reflexa	2						1	
Actinonaias ligamentina carinata	8							
Venustaconcha e. ellipsiformis	3							
Plagiola lineolata	8						1	
Obovaria olivaria								
Truncilla truncata	4							
Truncilla donaciformis				1				
Leptodea fragilis	2							
Potamilus alatus	9				2			
Potamilus ohioensis								
Ligumia recta	6							
Lampsilis t. teres			1					
Lampsilis radiata luteola								
Lampsilis ventricosa	21						1	
Lampsilis orbiculata								

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-15 (River Mile 26.9) to Site 0-16 (River Mile 23.7) in the lower Osage River.

Species	Site: 0-15				0-16			
	River Mile: 26.9				23.7			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta								
Anodonta imbecillis								
Anodonta g. grandis					2			
Anodonta grandis corpulenta								
Strophitus u. undulatus								
Arcidens confragosus								
Lasmigona complanata								1
Lasmigona costata								
Megaloniaias nervosa	609				19			
Tritogonia verrucosa	2			1			1	
Quadrula quadrula	1				1			1
Quadrula metanevra	7				6			1
Quadrula pustulosa	36				24			
Amblema p. plicata	10				1			
Fusconaia flava	52			1	5		2	
Cyclonaias tuberculata	46				209			
Pleurobema coccineum	58				14			1
Elliptio c. crassidens	1							
Elliptio dilatata	43				23		1	
Obliquaria reflexa			1				2	
Actinonaias ligamentina carinata	4		1		1			1
Venustaconcha e. ellipsiformis	1			1	1		1	
Plagiola lineolata	4		1		1		1	
Obovaria olivaria								
Truncilla truncata	1			1	1		1	
Truncilla donaciformis								
Leptodea fragilis	2	1	1					
Potamilus alatus	7				3			
Potamilus ohioensis								
Ligumia recta	1			1	4		1	
Lampsilis t. teres	1					1	1	
Lampsilis radiata luteola							1	
Lampsilis ventricosa	16				8			
Lampsilis orbiculata	1		2	5 2/2			1 1/2	1/2

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-17 (River Mile 22.2) to Site 0-18 (River Mile 21.5) in the lower Osage River.

Species	Site: 0-17				0-18			
	River Mile: 22.2				21.5			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta	1		1					
Anodonta imbecillis								
Anodonta g. grandis	1							
Anodonta grandis corpulenta								
Strophitus u. undulatus					1			
Arcidens confragosus								
Lasmigona complanata		1						1
Lasmigona costata								
Megaloniaias nervosa	7				77			
Tritogonia verrucosa	1				1			
Quadrula quadrula				1/2	8			
Quadrula metanevra	1				54			
Quadrula pustulosa	3				369			
Amblema p. plicata	4				6			
Fusconaia flava	1				71			
Cycloniaias tuberculata					267			
Pleurobema coccineum	2				142		3	1/2
Elliptio c. crassidens					2			
Elliptio dilatata				1/2	26			
Obliquaria reflexa			1		1			1
Actinoniaias ligamentina carinata					2		1	
Venustaconcha e. ellipsiformis					1			
Plagiola lineolata			1		6			
Obovaria olivaria								2/2
Truncilla truncata				1	5			
Truncilla donaciformis								
Leptodea fragilis	1				6			
Potamilus alatus					2			
Potamilus ohiensis								
Ligumia recta					5			
Lampsilis t. teres								
Lampsilis radiata luteola								
Lampsilis ventricosa	1				12			
Lampsilis orbiculata				2/2	4		2	5/2

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-19 (River Mile 17.6) to Site 0-20 (River Mile 13.6) in the lower Osage River.

Species	Site: 0-19				0-20			
	River Mile: 17.6				13.6			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta					8	1	4	
Anodonta imbecillis								
Anodonta g. grandis								
Anodonta grandis corpulenta								
Strophitus u. undulatus	1		1				1/2	
Arcidens confragosus								1 2/2
Lasmigona complanata					1			
Lasmigona costata								
Megaloniaias nervosa	9				182			
Tritogonia verrucosa			1				1	
Quadrula quadrula			1		1			
Quadrula metanevra	57				29			
Quadrula pustulosa	207				196			
Amblema p. plicata	14				7			
Fusconaia flava	91				51			
Cyclonaias tuberculata	69				108			
Pleurobema coccineum	107				89			
Elliptio c. crassidens								
Elliptio dilatata	16				17			
Obliquaria reflexa	1		1		3			
Actinonaias ligamentina carinata	5				5			1
Venustaconcha e. ellipsiformis								
Plagiola lineolata	13				15			1
Obovaria olivaria				1 3/2				
Truncilla truncata	11				27			
Truncilla donaciformis								
Leptodea fragilis	5				15			
Potamilus alatus	3				6			
Potamilus ohiensis						1		
Ligumia recta	6				9			
Lampsilis t. teres								1/2
Lampsilis radiata luteola								
Lampsilis ventricosa	25				43			
Lampsilis orbiculata	3	4 1/2		2/2	2	9 7/2	2 10/2	

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-21 (River Mile 10.3) To Site 0-22 (River Mile 5.6) in the lower Osage River.

Species	Site: 0-21				0-22			
	River Mile: 10.3				5.6			
	L	D	WD	SF	L	D	WD	SF
Cumberlandia monodonta								
Anodonta imbecillis								
Anodonta g. grandis	2		1			1		
Anodonta grandis corpulenta	1				5			
Strophitus u. undulatus				2				
Arcidens confragosus				1/2				
Lasmigona complanata							1	
Lasmigona costata								1
Megaloniaias nervosa	37						2	
Tritogonia verrucosa			1	1				
Quadrula quadrula			1	1	1		1	
Quadrula metanevra					10		2	
Quadrula pustulosa			1			1	1	
Amblema p. plicata	1				1		2	
Fusconaia flava			1		2		2	
Cyclonaias tuberculata								
Pleurobema coccineum							1/2	
Elliptio c. crassidens								
Elliptio dilatata				1				
Obliquaria reflexa			1		1		3	
Actinonaias ligamentina carinata					1			
Venustaconcha e. ellipsiformis								
Plagiola lineolata			1				2	
Obovaria olivaria								
Truncilla truncata				1			1	1
Truncilla donaciformis								1/2
Leptodea fragilis	13		1/2			5		
Potamilus alatus	6				9		2	
Potamilus ohioensis	15	2	2		18	4		
Ligumia recta	2				1			
Lampsilis t. teres				3			2	
Lampsilis radiata luteola				1	1			
Lampsilis ventricosa	1			1	6			
Lampsilis orbiculata			2 1/2			1	1	

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 1 (Continued). Species and numbers of naiades found from Site 0-23 (River Mile 1.9) in the lower Osage River.

Species	Site: 0-23			
	River Mile: 1.9			
	<u>L</u>	<u>D</u>	<u>WD</u>	<u>SF</u>
Cumberlandia monodonta				
Anodonta imbecillis				
Anodonta g. grandis	2		1	
Anodonta grandis corpulenta				
Strophitus u. undulatus				
Arcidens confragosus				
Lasmigona complanata	3			
Lasmigona costata				
Megaloniaias nervosa			1	
Tritogonia verrucosa				
Quadrula quadrula	1			
Quadrula metanevra	6			
Quadrula pustulosa	1		1	
Amblema p. plicata	3			
Fusconaia flava				
Cycloniaias tuberculata				
Pleurobema coccineum				
Elliptio c. crassidens				
Elliptio dilatata				
Obliquaria reflexa	3			
Actinoniaias ligamentina carinata				
Venustaconcha e. ellipsiformis				
Plagiola lineolata				
Obovaria olivaria				
Truncilla truncata				
Truncilla donaciformis	1			
Leptodea fragilis	6	3		
Potamilus alatus	34		1	
Potamilus ohioensis	3	3		
Ligumia recta				
Lampsilis t. teres	1			
Lampsilis radiata luteola				
Lampsilis ventricosa	1			
Lampsilis orbiculata				

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 2. Species and numbers of naiades found from Site T-1 (River Mile 32.8) to Site T-2 (River Mile 27.8) in Tavern Creek.

Species	Site: T-1				T-2			
	River Mile: 32.8				27.8			
	L	D	WD	SF	L	D	WD	SF
Anodonta imbecillis								
Anodonta g. grandis					1			
Strophitus u. undulatus	2				1			
Lasmigona complanata								
Lasmigona costata								
Tritogonia verrucosa								
Quadrula pustulosa								
Amblema p. plicata					1			
Fusconaia flava								
Cyclonaias tuberculata								
Pleurobema coccineum								
Elliptio dilatata								
Obliquaria reflexa								
Actinonaias ligamentina carinata								
Venustaconcha e. ellipsiformis	8							2
Truncilla truncata								
Leptodea fragilis					9			
Potamilus alatus	4				29			
Ligumia recta								
Ligumia subrostrata					1			
Lampsilis t. teres					1		1	
Lampsilis radiata luteola	10				82			
Lampsilis ventricosa	5				9			
Lampsilis reeviana brittsi					5			

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 2 (Continued). Species and numbers of naiades found from Site T-3 (River Mile 23.7) to Site T-4 (River Mile 20.4) in Tavern Creek.

Species	Site: T-3				T-4			
	River Mile: 23.7				20.4			
	L	D	WD	SF	L	D	WD	SF
Anodonta imbecillis								
Anodonta g. grandis								
Strophitus u. undulatus					1			
Lasmigona complanata								
Lasmigona costata				1	1			
Tritogonia verrucosa								
Quadrula pustulosa								
Amblema p. plicata	4							
Fusconaia flava	2				1			
Cyclonaias tuberculata								
Pleurobema coccineum								
Elliptio dilatata					6			
Obliquaria reflexa								
Actinonaias ligamentina carinata								
Venustaconcha e. ellipsiformis					5			
Truncilla truncata								
Leptodea fragilis								
Potamilus alatus	9				1			
Ligumia recta	1							
Ligumia subrostrata								
Lampsilis t. teres								
Lampsilis radiata luteola	39				35			
Lampsilis ventricosa	4				4			
Lampsilis reeviana brittsi								

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 2 (Continued). Species and numbers of naiades found from Site T-5 (River Mile 17.0) to Site T-6 (River Mile 14.1) in Tavern Creek.

Species	Site: T-5				T-6			
	River Mile: 17.0				14.1			
	L	D	WD	SF	L	D	WD	SF
Anodonta imbecillis	1							
Anodonta g. grandis	4							
Strophitus u. undulatus					2			
Lasmigona complanata								
Lasmigona costata	10							
Tritogonia verrucosa	11							
Quadrula pustulosa	1							
Amblema p. plicata	67				2			
Fusconaia flava	4							
Cyclonaias tuberculata								
Pleurobema coccineum								
Elliptio dilatata								
Obliquaria reflexa								
Actinonaias ligamentina carinata								
Venustaconcha e. ellipsiformis	11				22			
Truncilla truncata								
Leptodea fragilis	1				1			
Potamilus alatus	31				4			
Ligumia recta								
Ligumia subrostrata								
Lampsilis t. teres	2							
Lampsilis radiata luteola	76				7			
Lampsilis ventricosa	15				15			
Lampsilis reeviana brittsi								

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 2 (Continued). Species and numbers of naiades found from Site T-7 (River Mile 10.4) to Site T-8 (River Mile 6.8) in Tavern Creek.

Species	Site: T-7				T-8			
	River Mile: 10.4				6.8			
	L	D	WD	SF	L	D	WD	SF
Anodonta imbecillis								
Anodonta g. grandis					2			
Strophitus u. undulatus					1			
Lasmigona complanata								
Lasmigona costata	5				1			
Tritogonia verrucosa	6				1			
Quadrula pustulosa	1							
Amblema p. plicata	10				8			
Fusconaia flava	5							
Cyclonaias tuberculata								
Pleurobema coccineum				1/2				
Elliptio dilatata	52			1				
Obliquaria reflexa								
Actinonaias ligamentina carinata					1			
Venustaconcha e. ellipsiformis				1/2	2			
Truncilla truncata			1/2					
Leptodea fragilis			1		2			
Potamilus alatus	39				21			
Ligumia recta	2				1			
Ligumia subrostrata								
Lampsilis t. teres	10				15			
Lampsilis radiata luteola	102				59			
Lampsilis ventricosa	32				17			
Lampsilis reeviana brittsi	3							

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 2 (Continued). Species and numbers of naiades found from Site T-9 (River Mile 5.2) in Tavern Creek.

Site:		T-9			
River Mile:		5.2			
		<u>L</u>	<u>D</u>	<u>WD</u>	<u>SF</u>
<u>Species</u>					
Anodonta imbecillis					
Anodonta g. grandis	1				
Strophitus u. undulatus	2				
Lasmigona complanata	1				
Lasmigona costata	32			1	
Tritogonia verrucosa	5				
Quadrula pustulosa	3				
Amblema p. plicata	62				
Fusconaia flava	5				
Cyclonaias tuberculata				1	
Pleurobema coccineum	1				
Elliptio dilatata					
Obliquaria reflexa	2				
Actinonaias ligamentina carinata					1 1/2
Venustaconcha e. ellipsiformis	1				
Truncilla truncata			1		
Leptodea fragilis	4				
Potamilus alatus	71				
Ligumia recta					
Ligumia subrostrata					
Lampsilis t. teres	18				
Lampsilis radiata luteola	74		1/2		
Lampsilis ventricosa	36				
Lampsilis reeviana brittsi					

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 3. Species and numbers of naiades found from Site M-1 (River Mile 43.0) to Site M-2 (River Mile 35.0) in the Maries River.

Species	Site: M-1				M-2			
	River Mile: 43.0				35.0			
	L	D	WD	SF	L	D	WD	SF
Anodonta imbecillis								
Anodonta g. grandis								
Strophitus u. undulatus								
Lasmigona complanata								
Lasmigona costata								
Megaloniaias nervosa								
Tritogonia verrucosa								
Quadrula quadrula								
Quadrula pustulosa								
Amblesma p. plicata								
Fusconaia flava								
Pleurobema coccineum								
Elliptio dilatata								
Obliquaria reflexa								
Actinonaias ligamentina carinata								
Venustaconcha e. ellipsiformis								
Truncilla truncata								
Leptodea fragilis								
Potamilus alatus								
Potamilus ohioensis								
Ligumia recta								
Ligumia subrostrata								
Lampsilis t. teres								
Lampsilis radiata luteola					1			
Lampsilis ventricosa								
Lampsilis reeviana brittsi								

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 3 (Continued). Species and numbers of naiades found from Site M-3 (River Mile 32.1) to Site M-4 (River Mile 29.0) in the Maries River.

Species	Site: M-3				M-4			
	River Mile: 32.1				29.0			
	L	D	WD	SF	L	D	WD	SF
Anodonta imbecillis						1		
Anodonta g. grandis					3			
Strophitus u. undulatus	1				6	1		
Lasmigona complanata								
Lasmigona costata	1				2	1		
Megaloniaias nervosa								
Tritogonia verrucosa								
Quadrula quadrula								
Quadrula pustulosa								
Amblema p. plicata	1				10			
Fusconaia flava					5			
Pleurobema coccineum								
Elliptio dilatata					27			
Obliquaria reflexa								
Actinonaias ligamentina carinata								
Venustaconcha e. ellipsiformis	2				28			
Truncilla truncata								
Leptodea fragilis								
Potamilus alatus	1				2			
Potamilus ohioensis								
Ligumia recta								
Ligumia subrostrata					2			
Lampsilis t. teres					2			
Lampsilis radiata luteola	7				96			
Lampsilis ventricosa	5				23			
Lampsilis reeviana brittsi	1							

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 3 (Continued). Species and numbers of naiades found from Site M-5 (River Mile 26.7) to Site M-6 (River Mile 22.4) in the Maries River.

Species	Site: M-5				M-6			
	River Mile: 26.7				22.4			
	L	D	WD	SF	L	D	WD	SF
Anodonta imbecillis								
Anodonta g. grandis	16				47			
Strophitus u. undulatus					1			
Lasmigona complanata								
Lasmigona costata						1		
Megaloniaias nervosa								
Tritogonia verrucosa								
Quadrula quadrula								
Quadrula pustulosa								
Amblema p. plicata	1				1			
Fusconaia flava					1			
Pleurobema coccineum								
Elliptio dilatata					1			
Obliquaria reflexa								
Actinonaias ligamentina carinata								
Venustaconcha e. ellipsiformis		1 1/2			2			
Truncilla truncata								
Leptodea fragilis					1			
Potamilus alatus	5				1			
Potamilus ohiensis								
Ligumia recta								
Ligumia subrostrata					1			1/2
Lampsilis t. teres					1			
Lampsilis radiata luteola	49				65		1	
Lampsilis ventricosa	2	1			6			
Lampsilis reeviana brittsi					1			

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 3 (Continued). Species and numbers of naiades found from Site M-7 (River Mile 20.1) to Site M-8 (River Mile 16.8) in the Maries River.

Species	Site: M-7				M-8			
	River Mile: 20.1				16.8			
	L	D	WD	SF	L	D	WD	SF
Anodonta imbecillis					5			
Anodonta g. grandis	4				12			
Strophitus u. undulatus	1					1		
Lasmigona complanata								
Lasmigona costata								
Megaloniaias nervosa								
Tritogonia verrucosa					3			
Quadrula quadrula								
Quadrula pustulosa								
Amblema p. plicata				1/2	13			
Fusconaia flava			1		3			
Pleurobema coccineum								
Elliptio dilatata					1			
Obliquaria reflexa								
Actinonaias ligamentina carinata								
Venustaconcha e. ellipsiformis				1/2	23			
Truncilla truncata					1			
Leptodea fragilis						1		
Potamilus alatus	3				3			
Potamilus ohioensis								
Ligumia recta								
Ligumia subrostrata					1			
Lampsilis t. teres	1		2		31			
Lampsilis radiata luteola	2	2			71			
Lampsilis ventricosa					24			
Lampsilis reeviana brittsi					1			

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix B. (Continued)

Table 3 (Continued). Species and numbers of naiades found from Site M-9 (River Mile 11.8) to Site M-10 (River Mile 4.9) in the Maries River.

Species	Site: M-9				M-10			
	River Mile: 11.8				4.9			
	L	D	WD	SF	L	D	WD	SF
Anodonta imbecillis	1	1/2						
Anodonta g. grandis	12	1			12	1		
Strophitus u. undulatus		1			3			
Lasmigona complanata		1			10			
Lasmigona costata	18	2	1		5			
Megaloniaias nervosa					1			
Tritogonia verrucosa	4		1		3	1		
Quadrula quadrula			1		3			
Quadrula pustulosa		1	1		20			
Amblema p. plicata	109	1	2		750	1	1	
Fusconaia flava	3	1		1	2			
Pleurobema coccineum	2				1			
Elliptio dilatata	78		4		28			
Obliquaria reflexa	1		2		1	1		
Actinonaias ligamentina carinata					2			
Venustaconcha e. ellipsiformis	25	3	3				3	
Truncilla truncata	1	2	2		5			
Leptodea fragilis	5	1			17		1	
Potamilus alatus	11		1		25	1		
Potamilus ohioensis								
Ligumia recta	7	1						1
Ligumia subrostrata	2	3	2					
Lampsilis t. teres	11	2	1 1/2		8		1	
Lampsilis radiata luteola	204		1		41			
Lampsilis ventricosa	94	1			58	1		
Lampsilis reeviana brittsi								

L = Living
D = Dead
WD = Weathered Dead
SF = Subfossil

Appendix B. (Continued)

Table 3 (Continued). Species and numbers of naiades found from Site M-11 (River Mile 1.4) in the Maries River.

Species	Site: M-11			
	River Mile: 1.4			
	L	D	WD	SF
Anodonta imbecillis				
Anodonta g. grandis	36			
Strophitus u. undulatus				
Lasmigona complanata	2			
Lasmigona costata				1
Megalonaias nervosa				
Tritogonia verrucosa				
Quadrula quadrula				
Quadrula pustulosa				
Amblesoma p. plicata	8			
Fusconaia flava				
Pleurobema coccineum				
Elliptio dilatata				
Obliquaria reflexa				
Actinonaias ligamentina carinata				
Venustaconcha e. ellipsiformis				
Truncilla truncata				
Leptodea fragilis	2	1		
Potamilus alatus	3			
Potamilus ohioensis	2			
Ligumia recta				
Ligumia subrostrata				
Lampsilis t. teres				1
Lampsilis radiata luteola	3			
Lampsilis ventricosa	1			
Lampsilis reeviana brittsi				

L = Living

D = Dead

WD = Weathered Dead

SF = Subfossil

Appendix C.

Table 1. Water quality measurements at the sites sampled in the lower Osage River.

Site	River Mile	Temperature(°F)	pH	Alkalinity (ppm)	Total Hardness(ppm)	Dissolved Oxygen(ppm)	Turbidity (JTU's)
0-1	80.8	57.0	8.0	120	137	5.5	11.0
0-2	77.6	60.0	8.5	120	154	6.6	12.0
0-3	74.0	57.0	8.5	120	154	5.5	15.0
0-4	69.0	61.5	8.5	120	154	6.6	10.5
0-5	66.0	68.0	8.5	120	154	6.6	8.0
0-6	65.0	62.5	8.5	120	137	7.7	11.5
0-7	60.5	70.0	9.0	120	154	8.8	11.5
0-8	57.4	70.0	8.5	120	154	7.7	12.5
0-9	52.1	64.5	9.0	120	171	8.8	6.5
0-10	46.1	69.0	8.5	120	171	7.7	12.0
0-11	40.5	73.5	9.0	120	171	8.8	10.0
0-12	37.0	79.0	8.5	120	154	8.8	8.5
0-13	33.5	82.5	9.0	120	154	8.8	6.5
0-14	29.7	82.5	8.5	120	137	7.7	8.0
0-15	26.9	82.5	8.0	103	137	6.6	17.0
0-16	23.7	82.5	8.5	103	137	6.6	12.0
0-17	22.2	82.5	9.0	137	137	9.9	7.5
0-18	21.5	82.5	9.0	120	154	8.8	8.0
0-19	17.6	82.5	9.0	137	154	9.9	6.0
0-20	13.6	82.5	8.5	137	137	8.8	5.0
0-21	10.3	79.5	8.5	103	120	7.7	6.0
0-22	5.6	80.5	8.5	103	137	7.7	5.0
0-23	1.9	84.0	9.0	120	137	7.7	5.5

Appendix C. (Continued)

Table 2. Water quality measurements at the sites sampled in Tavern Creek.

Site	River Mile	Temperature(°F)	pH	Alkalinity (ppm)	Total Hardness(ppm)	Dissolved Oxygen(ppm)	Turbidity (JTU's)
T-1	32.8	68.0	9.0	188	205	7.7	14.0
T-2	27.8	77.0	9.0	223	240	7.7	5.0
T-3	23.7	84.0	9.0	223	240	9.9	4.0
T-4	20.4	73.5	9.0	188	205	9.9	7.0
T-5	17.0	84.0	9.0	223	240	9.9	5.0
T-6	14.1	70.0	9.0	188	205	7.7	3.0
T-7	10.4	87.0	9.5	205	223	12.1	8.0
T-8	6.8	73.5	9.5	188	205	8.8	4.5
T-9	5.2	86.0	9.5	223	223	9.9	6.0

Table 3. Water quality measurements at the sites sampled in the Maries River.

Site	River Mile	Temperature(°F)	pH	Alkalinity (ppm)	Total Hardness(ppm)	Dissolved Oxygen(ppm)	Turbidity (JTU's)
M-1	43.0	65.5	8.5	171	188	6.6	7.5
M-2	35.0	68.0	9.0	171	205	7.7	3.0
M-3	32.1	88.0	9.0	188	205	8.8	7.5
M-4	29.0	72.5	9.0	188	205	9.9	3.5
M-5	26.7	79.5	8.5	188	205	6.6	6.0
M-6	22.4	88.0	9.5	223	223	7.7	9.5
M-7	20.1	70.5	9.0	188	205	8.8	9.5
M-8	16.8	87.0	8.5	223	223	6.6	9.5
M-9	11.8	73.5	9.0	188	205	8.8	10.0
M-10	4.9	88.5	9.0	171	188	6.6	6.5
M-11	1.4	92.5	9.0	205	223	7.7	14.0

Appendix D. Typical naiad life cycle.

The life cycle for most species of naiades is very similar to that depicted on the next page.

The males shed sperm directly into the water. The eggs are passed to the gills in the female where they are fertilized and develop into glochidia. The glochidia are discharged into the water singly or in groups, depending on the species. If the glochidium comes into contact with the normal fish host it will attach to the fish and begin its parasitic stage. Glochidia cannot swim or crawl, and if a glochidium, after being discharged from the adult female naiad does not come into contact with the normal fish host it falls to the bottom and dies. A glochidium which attaches to a fish which is not a proper host will be sloughed off after a period of time and will die. The parasitic stage lasts from a week to several months, depending on the species, water temperature, and other factors. The glochidium develops into a juvenile naiad while encapsulated upon the fish and drops from the host to begin growth on the stream bottom. Thin-shelled species may live only 4 to 10 years, but thicker-shelled river species normally live 20 to 40 years or more (Stein 1971).

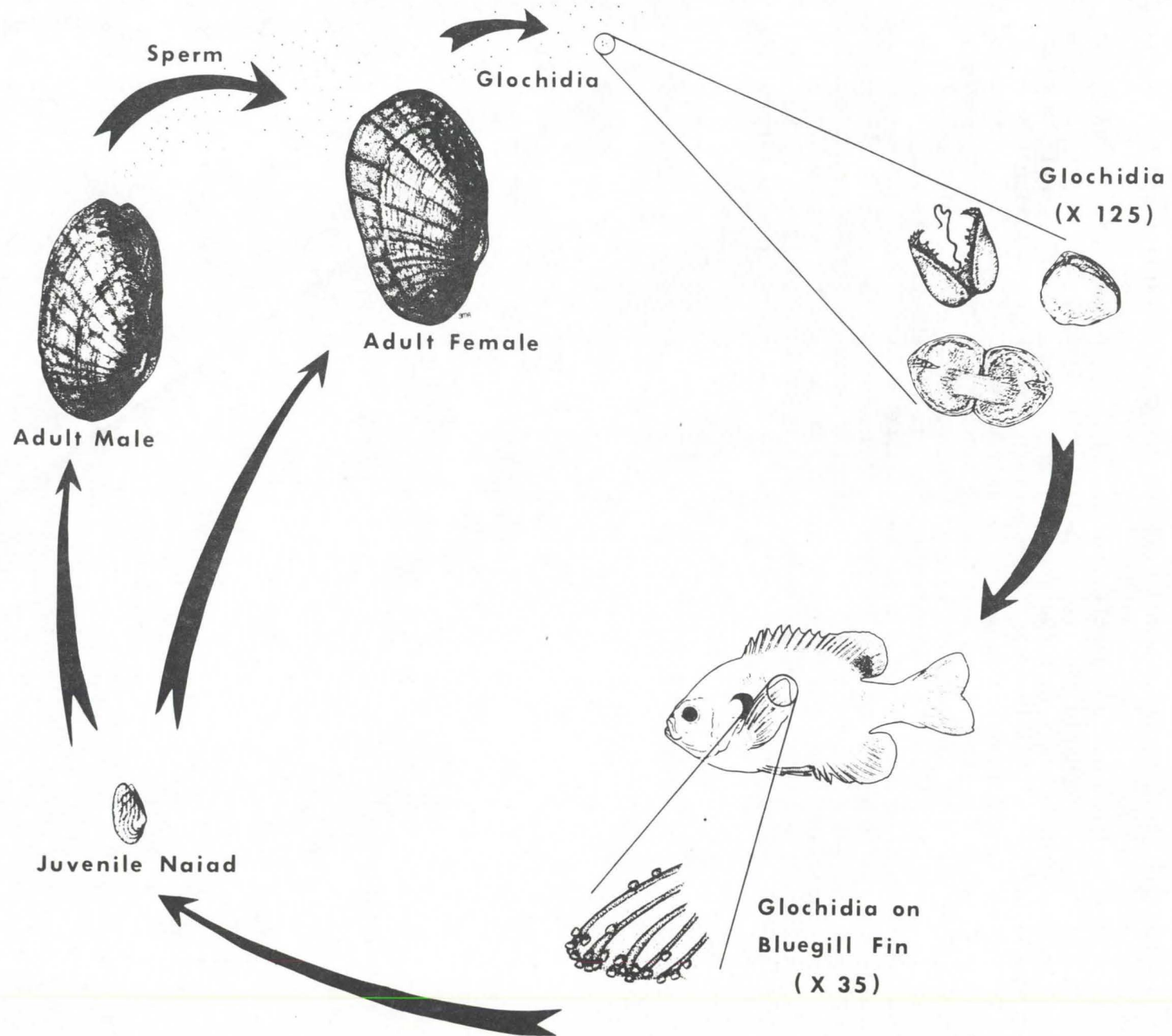


Figure 1. Typical naiad life cycle depicting the various stages. The life cycle for most species of naiades is very similar to that depicted here.

